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Monday, 20th April 1885.

ROBERT GRAY, Esq., Vice-President, in the Chair.

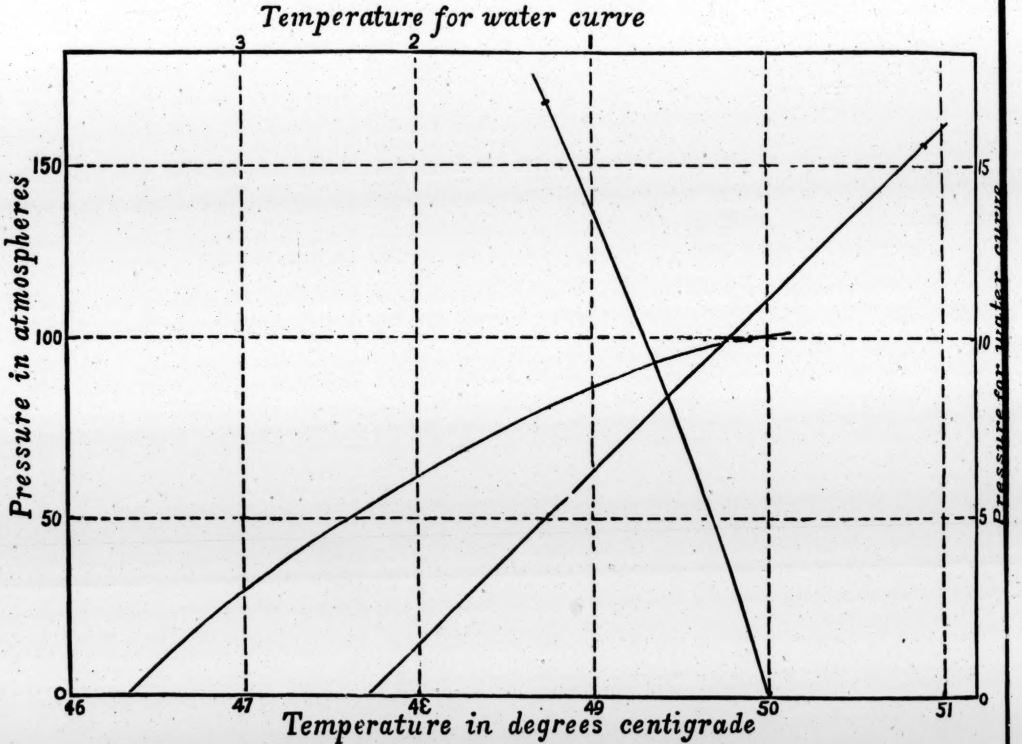
The following Communications were read :—

1. Effect of Pressure on the Temperature of Minimum Compressibility of Water. By Professor Tait.

2. Note on the Variation by Pressure of the Melting-Point of Paraffin, &c. By W. Peddie, Esq. Communicated by Professor Tait.

As the result of Andrews' experiments on the boiling-points of substances, we have the law enunciated that There is a critical temperature for every vaporous or gaseous substance; such that, only when its temperature is below this, can the substance be reduced to the liquid form by any pressure, however great. Similarly, a law may be laid down regarding the passage from the liquid to the solid state, or *vice versâ.* Thus we may say that There is a critical temperature for every solid substance, which contracts in the act of liquefaction, such that only when its temperature is above this, can the substance be reduced to the liquid form by any pressure, however great; and for every liquid substance, which contracts in the act of solidification, such that only when its temperature is below this, can the substance be reduced to the solid form by any pressure, however great.

There is as yet no experimental evidence for this law, but I hope to be able to communicate before long to the Society the result of experiments in this direction. Meantime I wish to draw attention to the peculiar behaviour of paraffin under pressure, as brought out by some experiments of Bunsen's, undertaken for a different purpose.* His results are shown graphically in the accompanying diagram. The curved lines represent the variation of the melting-point with



pressure. Pressure is measured upwards, and temperature horizontally. The least curved line sloping up is that of spermaceti. The markedly curved line is that of paraffin. The line sloping down is that of water. The direction of slope shows that the substance expands in the act of freezing, as its melting-point is lowered by pressure. If the paraffin curve continues to bend at the same rate as the pressure is increased, beyond the point reached in Bunsen's experiments, its tangent line will become horizontal, and the curve will be concave to the temperature axis. That is to say, paraffin under these pressures will behave as water does, *i.e.*, will expand in the act of freezing. The temperature corresponding to the point

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* *Pogg. Ann.*, lxxxi., Dec. 1850.

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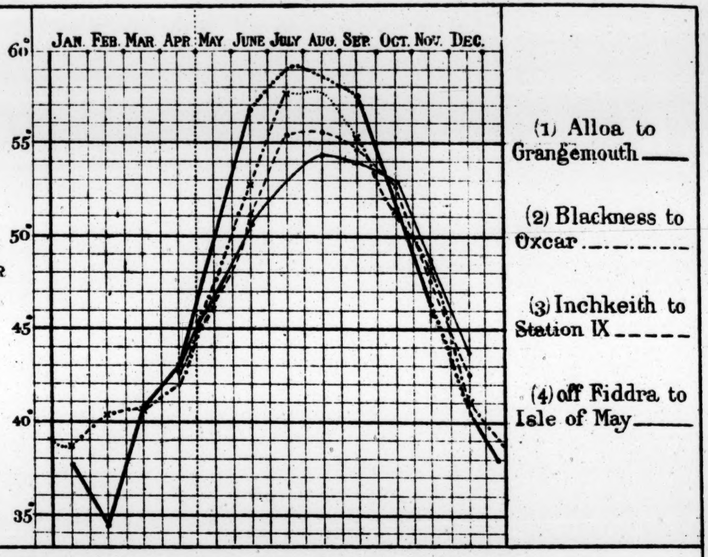
Fig. 1.

MEAN MONTHLY TEMPERATURE OF THE SURFACE WATER IN THE FIRTH OF FORTH, 1884-85.
Plotted by rectangular coördinates



MEAN MONTHLY TEMPERATURE OF THE SURFACE WATER IN THE FIRTH OF FORTH, 1884-85. Plotted by polar coördinates.

Fig. 2.

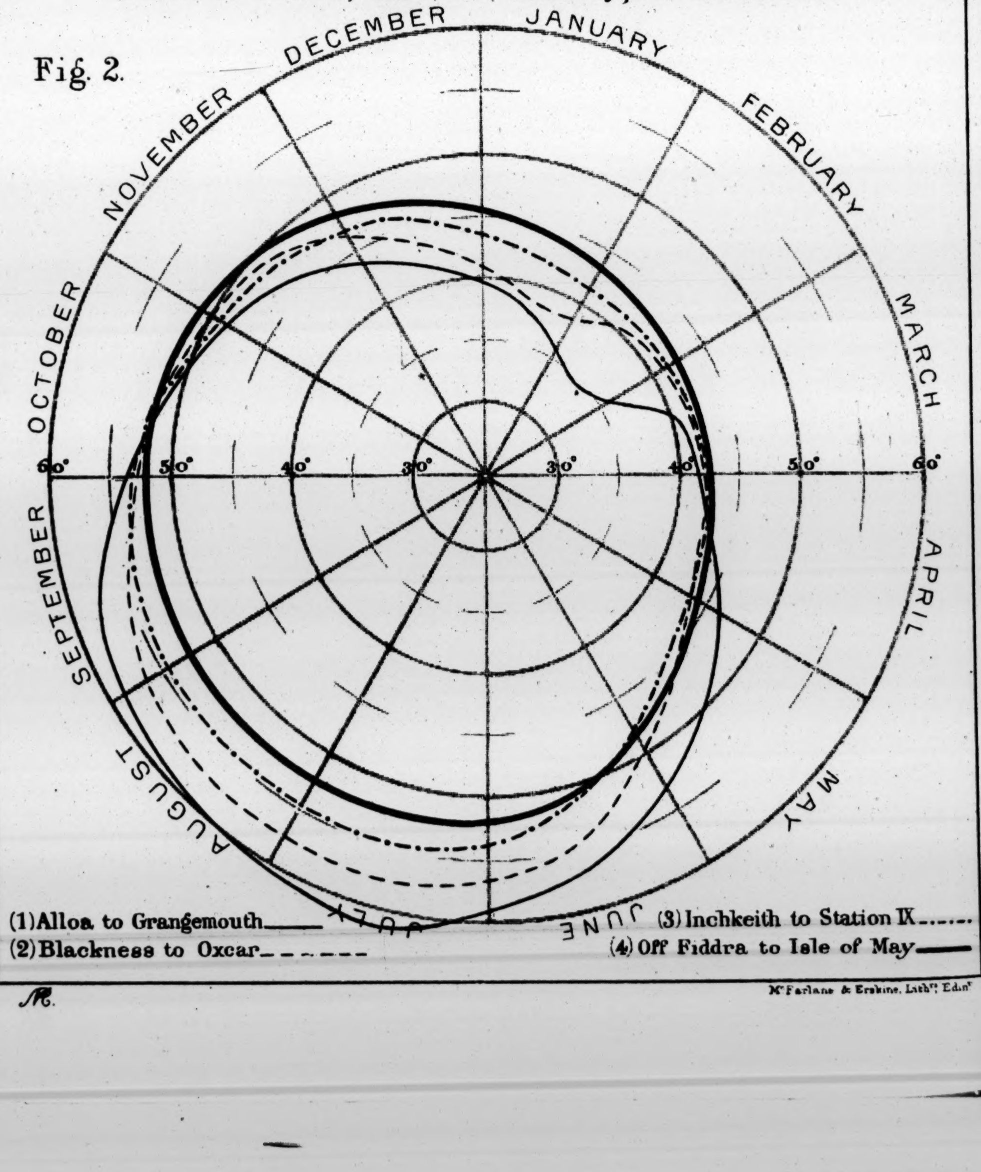


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Fig. 1. SERIAL TEMPERATURE OBSERVATIONS: SURFACE WATER OF FIRTH OF FORTH.

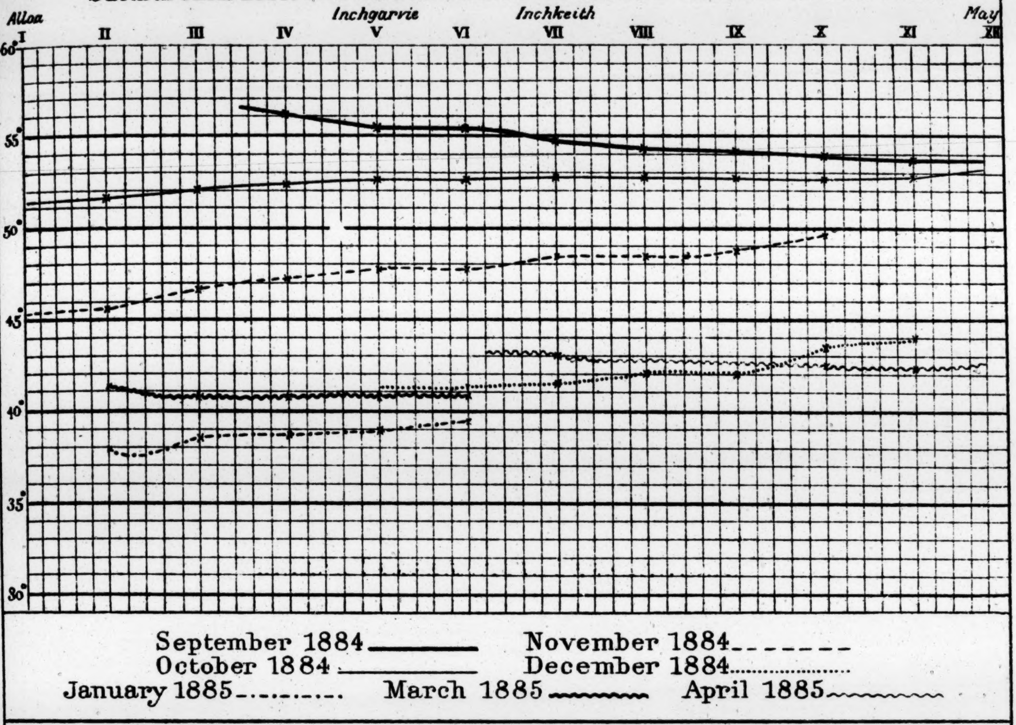
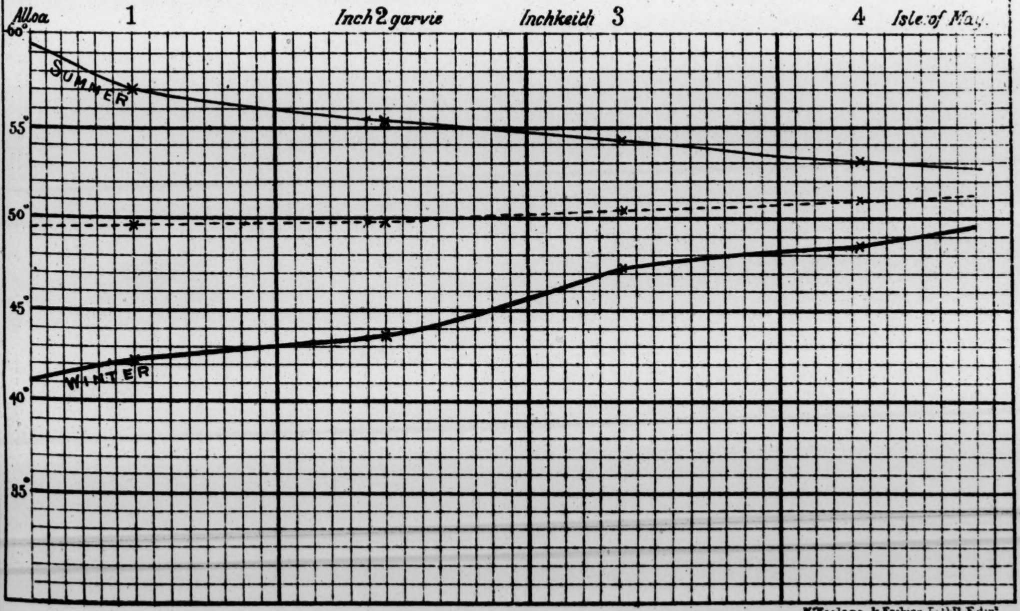


Fig. 2.

SURFACE WATER.

MEAN DISTRIBUTION OF TEMPERATURE SUMMER (June-Sept.) AND WINTER (Oct.-Jan.)



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where the tangent is horizontal would be a critical temperature of a peculiar nature, both forms of the above law applying to it. I hope to be able to settle this point in the experiments above proposed.

3. Note on the Thermal Effects of Tension in Water. By G. N. Stewart, Esq. Communicated by Prof. Tait.

4. On the Temperature of the Water in the Firth of Forth. By Hugh Robert Mill, B.Sc., F.C.S. (Plates VI., VII.).

The temperature of water can be ascertained much more easily than that of air, and with far greater accuracy; yet comparatively little has been done by meteorologists in the way of obtaining data bearing on the distribution of temperature in rivers and in estuaries. Some observations of great value have been discussed by Mr Buchan in the Scottish Meteorological Society's Journal,* but these were discontinued after a few years.

It would be extremely interesting, and would lead to valuable results, if at a number of stations on the River and Firth of Forth, for example, the temperature of the water could be ascertained daily, and also the temperature of the tributary streams at short intervals of time. The value of such work would of course be enormously increased if it could be applied to other river-systems, so as to admit of comparisons between them. A very complete system of observation is at present being arranged by the Tweed Commissioners, from which interesting results regarding the Tweed may be expected.

The temperature of a large river depends, in the first place, on the temperature of the deep lakes which supply it, where, as on the Forth, such lakes exist; secondly, on the temperature of the feeders, which is affected by the temperature of the rain falling, and by that of the land over which it runs. In the third place, the colour and transparency of the water, depth of river, rapidity of flow, and nature of the banks modify the effect of radiation; and, lastly, the proximity of the sea, and consequent effect of tide, must be considered.

Observations have been made at the Scottish Marine Station since May 1884, and although nothing final can be said, it has been considered advisable to make the results public. This is done not only to suggest the general law governing the distribution of temperature in an estuary at different seasons, but to get the benefit of any suggestions that may be made as to the carrying on of the work in future.

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* *Jour. Scot. Met. Soc.*, new series, i. p. 256; v. p. 251.

The methods of observing the temperature of water are extremely simple. For the surface it is sufficient to place a thermometer for a few seconds—the time must be greater the more sluggish the instrument—in a bucket of ~~the~~ water, or to dip the thermometer in the water and read it rapidly on its withdrawal. In using the latter method, the thermometer case must terminate in a little cup to contain enough water to cover the bulb. For depths below the surface the Negretti and Zambra thermometer in the Scottish frame * has been found most suitable.

A special arrangement requires to be made in order to fix continuously immersed self-registering thermometers at the surface and bottom, so that they will not have their distance from the bottom and surface altered by the rise and fall of the tide. This was accomplished at Granton by hanging the surface thermometer B (fig. 1), an ordinary Miller-Casella self-registering maximum and minimum instrument, to an anchored buoy A. The bottom thermometer was also attached to the buoy with a line long enough to reach the bottom at the highest spring tides. In order to prevent the ther-

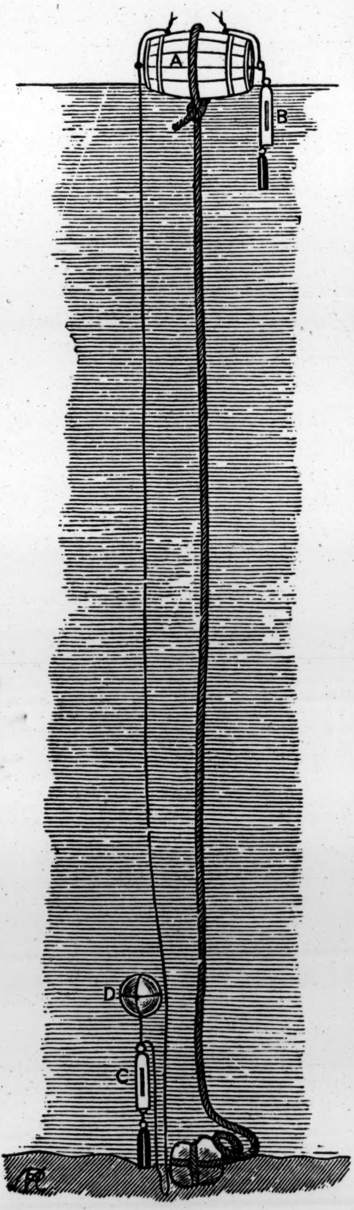

Fig. 1.

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* *Proc. Roy. Soc. Edin.*, xii. p. 927.

mometer C from lying on the mud at low water, a glass float D was employed, which was strong enough to keep the thermometer upright, but not to lift the weight attached to it. The accompanying illustration (fig. 1) represents the arrangement at low water.

In the observations to be described the corrections for the thermometers have not been applied, as from the small number of readings obtained at each station the true temperatures can be of little importance, and since the same thermometer was used during each set of observations, the value for comparative purposes is not diminished.

The mean temperature of the sea for each month during a period of five years (1858–1863) at Dunbar and at North Berwick, and for a similar period (1864–1866) at the Chain Pier, Trinity, is given in the following table (Table I.).* All three stations show one well-marked annual maximum between July and August, and one minimum in February. The range is greatest at Trinity and least at Dunbar; and twice in the year, about April and November, the three curves almost coincide.

TABLE I.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Trinity, .	39·4	36·4	38·7	43·8	49·0	53·7	56·0	56·2	53·6	49·6	44·9	43·8	47·1
North Berwick,	40·5	40·0	41·1	44·2	47·8	52·2	55·6	55·6	54·8	50·9	45·5	42·2	47·5
Dunbar, .	41·1	40·1	41·7	44·5	48·2	52·4	55·4	55·8	54·8	50·7	46·2	42·9	47·7

Table II. shows the means for one year at Granton Quarry of the surface temperature, and Table III. gives the same with the bottom temperature, and that of the air at 9 A.M. and 9 P.M., and the respective maxima and minima observed. In the quarry the effects of the proximity of land are very clearly observable, and the

TABLE II.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Granton, .	37·5	38·8	40·4	42·0	50·4	54·7	57·4	58·6	55·3	49·4	44·4	39·7	47·3

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* *Jour. Scot. Met. Soc.*, new series, i. p. 256.

thermal conditions are complicated by the nature of the tidal basin* and by the peculiar relations borne to it by the River Almond and Cramond Island.†

Table III.

Month.	Temperature of Air.				Of Surface Water.				Of Bottom Water.			
	Max.	Min.	Mean.		Max.	Min.	Mean.		Max.	Min.	Mean.	
			at 9 a.m.	at 9 p.m.			at 9 a.m.	at 9 p.m.			at 9 a.m.	at 9 p.m.
1885.												
Jan.	49·0	22·0	37·0	37·4	39·5	32·1	37·4	37·6	40·0	35·1	37·8	37·7
Feb.	58·0	24·0	41·0	41·3	42·0	32·9	38·8	38·9	41·7	37·0	39·2	39·2
Mar.	50·8	29·0	40·9	39·9	43·5	39·4	40·3	40·5	46·0	39·3	40·4	40·7
Apr.‡	49·0	30·0	42·6	41·2	43·7	38·9	42·0	41·9	43·5	38·9	41·8	42·1
1884.												
May§	69·5	36·5	50·6	49·6	53·5	48·7	50·0	50·8	52·0	49·1	50·1	50·4
June	70·0	41·4	56·0	54·4	58·2	50·0	54·4	55·1	57·0	50·7	54·1	54·2
July	74·0	41·7	57·3	57·0	60·7	52·7	57·3	57·5	59·2	55·0	57·1	56·9
Aug.	77·8	43·1	58·8	57·4	60·5	56·2	58·7	58·4	59·6	55·0	58·1	58·2
Sept.	69·3	30·0	55·1	54·2	56·0	50·5	55·4	55·2	56·3	52·0	54·7	54·9
Oct.	70·1	32·0	48·7	48·2	53·5	41·3	49·3	49·5	54·1	43·7	49·6	49·9
Nov.	63·0	23·0	41·9	41·6	50·0	37·5	44·3	44·4	50·0	39·3	44·8	44·7
Dec.	58·0	25·0	39·1	39·0	44·0	32·0	39·6	39·8	45·0	37·0	40·6	40·6
Year,	77·8	22·0	47·1	47·2	60·7	32·0	47·3	47·3	59·6	35·1	47·3	47·4

The curves for these data show precisely the same state of matters as those for Trinity, North Berwick, and Dunbar, so far as the date of maximum and minimum is concerned. They show, too, that from May to September the surface water is warmer than the bottom water, while from October to April it is colder, and that the temperature of the air is on the whole lower than that of the water.

The peculiar conditions of Granton Quarry make it impossible to accept its temperature indications as being applicable to the Firth outside; they must be viewed merely as exaggerated examples of the effects of land on water.

All the observations of surface temperature made in the Firth, several hundreds, have been classified for each month into four regions (see Table IV.). Under 1 is given the mean of all observations made at the stations marked on the chart (Plate III.), I., II., III., that is, from Alloa to the Hen and Chickens buoy; under 2, those made at IV., V., VI., from Blackness to Oxcar; under 3, those at VII., VIII., IX., from Inchkeith ten miles seaward; and under 4 all farther to the east.

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* *Proc. Roy. Soc. Edin.*, xii. p. 927.

† *Ibid.*, xiii. p. 59.

‡ Up to 17th.

§ From 15th.

TABLE IV.

Place.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	37·9	36·5	41·0	44·5	...	56·7	...	...	57·4	51·7	46·1	...
2	38·7	40·3	40·7	43·0	49·0	52·7	57·8	...	55·2	52·2	48·1	40·8
3	...	...	...	42·9	...	51·0	55·3	55·6	54·9	52·8	47·6	42·3
4	...	...	...	42·5	...	50·9	...	54·3	54·0	52·8	48·8	43·7

The general result of the observations is that in the landward part of the Firth the range of temperature is greater and the period of the maximum earlier than farther seaward; and that as the sea is approached the range becomes less and the date of the maximum is retarded. Thus in 2 and 3 the maximum occurs in July, in 4 not until the end of August. No doubt observations made at Alloa would show a winter minimum of 32°, or nearly so, and the summer maximum would probably approach 70°. The extreme probable range at Alloa is 40° in the year; at Queensferry a range just half of that, 20° from 58° to 38°, has been observed; and at the Isle of May it is most likely that the annual range will not much exceed 10°. The extreme temperatures observed near the Isle of May were in fact 55° in August and 43° in December.

The mean temperature for the year appears not to vary more than half a degree from 47°·5 in any part of the Firth; but an extended series of observations is necessary in order to clear up this point.

In order to show the continuity of the seasons, the temperature curves for surface water at North Berwick and at Granton were drawn on a new plan. A circle is divided into 12 sectors, one for each month, and the temperatures are measured on the radii, concentric circles being drawn for 30°, 40°, 50°, and 60°. The line representing the temperature becomes a closed curve, and the regularity of its form is very striking. The curves on Plate VI. fig. 2, representing the monthly means in the four divisions of the Firth, are less regular, in consequence, probably, of the intermittent nature of the observations. In Plate VI. fig. 1 the same curves are shown.

This plan of plotting curves by means of polar instead of rectangular co-ordinates will be found to have many advantages in meteorological work. I do not know whether it has been employed before for the purpose.

The daily range of temperature is not known. It is believed not to exceed 1° in the open sea, but in shallow or muddy water it must be much greater. In the intensified conditions of the Granton Quarry, the greatest daily range observed during September, October

TABLE V.

Month.	Station.	JUNE TO SEPTEMBER.		
		Surface.	Intermediate.	Bottom.
June,	V.	52·4	51·3	50·9
July,	,,	57·8	54·2	54·2
September,	,,	55·3	54·9	55·3
Mean,		55·2	53·5	53·5
June,	VII.	51·0	48·5	48·0
August,	,,	57·8	54·2	54·2
September,	,,	55·0	54·2	54·0
Mean,		54·6	52·3	52·1
June,	XII.	50·9	47·4	47·7
August,	,,	54·3	53·6	54·0
September,	,,	54·5	54·3	54·1
Mean,		53·2	51·8	51·9
		OCTOBER TO APRIL.		
October,	V.	52·4	52·6	52·5
November,	,,	47·7	49·1	49·1
December,	,,	41·2	42·3	42·6
January,	,,	38·8	39·4	39·5
March,	,,	41·0	40·3	40·3
Mean,		44·2	44·7	44·8
October,	VII.	52·7	52·8	53·0
November,	,,	48·3	49·4	49·4
December,	,,	41·7	42·2	43·1
Mean,		47·6	48·1	48·5

and November, by means of the registering thermometer, was 8°·7, and the average 1°·9. It is almost certain, arguing from analogy, that the daily range is, like the annual range, greatest in the river and least in the sea.

The number of observations made at depths beneath the surface has not been so great; but a considerable mass of facts has been accumulated on the subject of the bathymetrical distribution of temperature in the Firth.

The surface, bottom, and intermediate temperatures were regularly ascertained at Inchgarvie in from 30 to 40 fathoms; at Inchkeith in from 15 to 20 fathoms; and near the Isle of May, where the depth varied from 20 to 25 fathoms. Table V. gives the means for each month, and for the summer and winter periods.

From June (or probably May) to September the water at the surface is warmer than that below; but from October to April this effect is reversed, the water at the surface being then colder. It was pointed out some months ago[*] that the density of bottom water in the Firth was always slightly greater than that of surface water at the same temperature, and it is probable that the difference in density is sufficient to account for the apparent anomaly of cold water overlying warmer water during at least half the year. The reductions necessary to settle this point are tedious, and have not yet been completely worked out.

TABLE VI.

	1. Alloa to Blackness.			2. Blackness to Oxcar.			3. Oxcar to Inchkeith.			4. Farther Seaward.		
	Surf.	Bot.	S. – B.	Surf.	Bot.	S. – B.	Surf.	Bot.	S. – B.	Surf.	Bot.	S. – B.
Mean for May to September,	57·1	56·4	0·7	53·7	51·4	2·3	54·2	52·2	2·0	52·5	51·3	1·2
Mean for October to January,	45·2	45·8	-0·6	44·9	45·9	-1·0	47·6	48·4	-0·8	50·8	51·2	-0·4
Mean for the Year,	50·0	50·0	0·0	49·3	48·6	0·7	51·3	50·6	0·7	51·7	51·2	0·5

Table VI. gives the seasonal means for *all* the comparisons of bottom and surface temperatures in the four divisions of the Firth,

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[*] "On the Salinity of the Water in the Firth of Forth," *Proc. Roy. Soc. Edin.*, xiii. p. 32.

TABLE VII.

	Alloa. I.	II.	III.	IV.	Inch-garvie. V.	VI.	Inch-keith. VII.	VIII.	IX.	X.	XI.	Isle of May. XII.
September, . .	...	...	57·4	56·7	55·3	55·7	55·3 54·6	... 54·2	... 54·1	... 54·0	... 53·9	... 53·8
Fall in each 5 miles				0·7	1·4	−0·4	0·4	0·4	0·1	0·1	0·1	0·1
October, . .	51·4	51·5	52·1	52·3	52·4	52·5	52·7	52·8	52·8	52·6	52·9	53·0
Rise in each 5 miles		0·1	0·6	0·2	0·1	0·1	0·2	0·1	0·0	−0·2	0·3	0·1
November, . .	45·1	45·6	46·9	47·2	47·8	47·7	48·3	48·4	48·9	49·6	...	...
Rise in each 5 miles		0·5	0·3	0·3	0·6	−0·1	0·6	0·1	0·5	0·7		
December, . .	...	...	...	...	41·2	41·3	41·6	42·2	42·4	43·6	43·8	...
Rise in each 5 miles						0·1	0·3	0·6	0·2	1·2	0·2	
January, . .	...	37·6	38·2	38·7	38·9	39·7	...	...	...	...	...	...
Rise in each 5 miles			0·6	0·5	0·2	0·8						
March, . .	...	41·2	40·8	40·8	41·0	41·0	...	...	...	...	...	...
Rise in each 5 miles			−0·4	0·0	0·2	0·0						
April, . .	...	...	...	...	...	43·2	43·0	...	...	43·2	43·2	43·5

including the cases considered in Table V. The former table shows that the upper half of the water has nearly the whole difference of the temperature to account for, and it is probable that quite a small layer is heated above or cooled below the temperature of the great bulk of the water.

The figures already given may be considered as describing the variation of temperature with the seasons at the various parts of the Firth; the variation of temperature with position at the same time of year must also be considered. The temperatures observed in the various long water-sampling trips are given in Table VII. They show how, in the 55 miles between Alloa and the Isle of May, the temperature is never at any one time uniform, and this is very distinctly brought out by the curves of these figures. With the exception of the first expedition (in September), all of these were made in the water-winter, that is at a time when the radiation from the land and sea at night was greater than that to them by day, and when as a consequence the shallower and more land-locked waters were colder than those deeper and nearer the sea. The curves have all an upward slope towards the sea in consequence, with the exception of that for September and that for April. The latter is a nearly straight line, showing that at present (20th April 1885) the lower reaches of the Firth are at an almost uniform temperature of 43° (see Plate VII. fig. 1). Collecting all the available observations of surface temperature, and taking the mean of those in the four divisions of the Firth for each half-yearly period, the following table (VIII.) is arrived at:—

TABLE VIII.

	1.	2.	3.	4.
Summer (June–September) .	57·0	55·3	49·2	48·0
Winter (October–January) .	42·3	43·7	47·3	48·4

The diagram (Plate VII. fig. 2) shows that in summer the temperature falls pretty rapidly from Alloa to Inchgarvie, and more slowly right out to sea. In winter this state of matters is exactly reversed, the temperature rising continuously from the river seawards. The mean of the two is a nearly straight line which almost coincides with the line of 50°. The number of observations made use of in drawing the winter curve was much greater than that available for the summer line, a fact which possibly accounts for the mean between the two not being parallel to the axis of x.

The mean rise or fall of temperature going along the central line of the Firth at any time during the year is 0°·07 per mile. In April and October it is much less; in December and August much more.

A great deal has to be done in the way of studying the effect of shallow water, and of the proximity of land in modifying the temperature in cross sections of the Firth. From what has been done already, it appears *possible* that if a large number of temperature observations could be taken at different parts of the Firth during all seasons for a few years, data would be procured which might render the thermometer a valuable aid in determining the position of a vessel at night or in a fog.

At present (April 1885) the temperature of the River and Firth of Forth is in a position something like the following:—

Loch Ard, the principal source of the Forth proper, is at a temperature of 42°·5, so far as regards the water in the six feet nearest the surface at any rate. The shallow river issuing from the loch and flowing slowly over a stony bed was, on the day of my visit last week, of the temperature 45°. At Kippen, 16 miles farther on, it was 47°·3, and some of the small tributary burns were as high as 49°·5. At Gargunnock, 7 miles from Kippen, the temperature of the water was 46°·6. The Teith, which is a larger river than the Forth, and joins it near Stirling, had a temperature of 42°·3 at Callander, which was reduced to 42° at Doune, 9 miles farther on, and 6 miles from the junction. This evidently shows that the lochs that feed the Teith—Vennachar, Katrine, and Lubnaig—must be colder than Loch Ard: but I had not time to ascertain this by a visit. At Stirling the river had the temperature of 45°, which gradually fell to 43°·5 at Kincardine; and the whole Firth, from there to beyond the Isle of May, is at a temperature not more than half a degree different from this. This uniformity will probably not last for a week. It is a state of matters represented by the upward sloping winter-temperature curve being in a horizontal position preparatory to its assuming the downward direction characteristic of summer.

It is curious how great a difference there is between the temperature of rivers in the same district and apparently under the same conditions; and the only way to arrive at an understanding concerning it is by having simultaneous observations at different places.

The basin of the Forth is very poorly supplied with meteorological stations, and if anything like thorough knowledge of the physical conditions of this river system is to be obtained, such stations must be set in action. This could be best done by the assistance and cooperation of the proprietors on the banks of the river, who would doubtless in time reap practical advantages from the work done.

I have to thank Mr T. Morton Ritchie, B.Sc., for his valuable help in making many of the observations described in this paper; various members of the scientific staff of the Scottish Marine Station, where the work was carried on; and in particular the crew of the "Medusa," without whose care and assistance it would have been impossible to do much of the deep-sea work.

5. The Relations of the Yolk to the Gastrula in Teleostean Embryos. By J. T. Cunningham, B.A.

(*Abstract*).

In the course of my studies on the development of marine osseous fishes, I have recently made at the Scottish Marine Station some observations on the living ova of the cod (*Gadus morrhua*, L.), haddock (*G. æglefinus*, L.), and whiting (*G. merlangus*, L.). The eggs of all these species are pelagic; that is to say, they are not adhesive, and are of less specific gravity than the sea water into which they are shed by the parent fish, and they consequently undergo development at or near the surface of the sea. They float at the surface of still sea water in a glass vessel such as was used to contain them in the laboratory, and at the surface of the sea in calm weather. But if the glass vessel be shaken the eggs are dispersed throughout the water within it, and when the surface of the sea is agitated by wave motion, a similar effect is produced, the buoyant eggs are dispersed through the water to a depth depending on the intensity of the agitation. Like most pelagic eggs, those under consideration are transparent, and each egg is separate and spherical. The eggs of the whiting are the smallest of the three species, the cod's next in size, and the haddock's largest. The diameter of the latter measures 1·45 mm. Owing to their convenient size and perfect transparency, the changes which occur in the embryonic period of development—that is, from fertilisation to hatching—can be followed with great ease by placing eggs at successive stages under the microscope, a combination of lenses being used magnifying about 40 diameters. The eggs were obtained and fertilised by squeezing them from the ripe fish on board a fishing boat into a bottle of sea water, into which milt from a ripe male had previously been allowed to fall.

The eggs of all the species mentioned have a very similar structure; the yolk is perfectly structureless, the vitelline membrane very thin, and the pervitelline space of moderate size. At one pole of the yolk is the blastodisc, a cap of protoplasm tinged at the earlier stages of development of a light terra-cotta colour. This colour gradually disappears towards the end of the process of simple segmentation.

The processes of the development in pelagic Teleostean ova have been recently described by various naturalists, and there is a general agreement in the descriptions concerning the main features. Full details of my own observations will appear shortly in the *Quarterly Journal of Microscopical Science.* All I wish to do here is to review synthetically certain phenomena of the development, their probable significance as evidences of remote ancestral conditions, and their homological relations to phenomena in the development of other vertebrate forms.

The development of a pelagic Teleostean ovum, and doubtless of all Teleostean ova, differs from that of all other vertebrate ova in the fact that invagination takes place round the whole periphery of the blastoderm simultaneously. This invagination is completed before the blastoderm begins to grow over the yolk mass, and the invaginated layer causes the peripheral region of the blastoderm to be thicker than the central part. The thickened part is known as the germinal ring. Along one radius the blastoderm is thicker than elsewhere, even before the inflected layer appears, and beneath this radius the inflected layer when it is formed extends further inwards than elsewhere. The inflected or invaginated layer when it appears constitutes part of the blastoderm, and is situated between the rest of the blastoderm and the yolk mass. The superficial layer of the yolk mass beneath the blastoderm is protoplasmic and nucleated, though not divided into cells. This layer is called the periblast, and at a later stage forms a continuous covering all over the yolk mass, from which it is never distinctly separated. The thickened radius of the blastoderm is the first indication of the embryo, and is known as the embryonic rudiment. As the blastoderm grows over the yolk, the germinal ring, exclusive of the embryonic rudiment, remains of the same breadth, but the rudiment grows in length at its posterior end, while the anterior end, that which is at first situated near the centre of the blastoderm, does not alter its position. The posterior end of the embryonic rudiment is always at the edge of the growing blastoderm. Towards the close of the process of envelopment of the yolk by the blastoderm, the germinal ring is gradually absorbed into the embryonic rudiment, and finally the whole of it is seen to form part of the dorsal region of the embryo. In this way the whole of the invaginated layer comes to lie beneath the axis of the embryo. There can be little doubt from what is known concerning the development of other vertebrate forms, that the invaginated layer ultimately forms the dorsal wall of the intestine, the floor of which is derived from the periblast.

It was maintained some years ago by the German embryologists, His and Rauber, that the explanation of the formation of the dorsal region of the embryo out of the germinal ring was, that the two halves of the ring were gradually fused together by concrescence taking place at the point where they were continuous with the posterior end of the embryonic rudiment, and that the edge of the blastoderm was the blastopore, which was thus situated along the median dorsal line of the embryo. This view is generally accepted by more recent students of Teleostean development, but no examination has been made of the theory or process in detail. His and Rauber, in their exposition of the concrescence theory, connected it with the discussion of facts concerning the development of the medullary folds in Elasmobranchs. It seems to me important that it should be clearly understood that the process of concrescence which undoubtedly takes place in Teleostean ova is simply the closing of the dorsal blastopore, which has become distended by the increased bulk of the yolk developed in the ventral hypoblast of the original gastrula. The nerve cord in its original condition was a thickened line of epiblast surrounding the blastopore, and the formation of the medullary canal by which the nerve cord is removed from the surface of the body, is a process which originally took place after the closing of the blastopore. The two processes are only accidentally connected with one another in actual development; morphologically they are quite independent.

Since the dorsal hypoblast in the Teleostean ovum is invaginated round the whole edge of the blastoderm, this edge forms the lip of the true primitive blastopore, and is homologous with the lip of the blastopore in the ancestral gastrula. As far as can be judged from the study of living pelagic ova, the posterior end of the blastopore is on the dorsal surface, and no part of it extends round the end of the body to the ventral side of the embryo. In the Amphibian ovum invagination of the dorsal hypoblast does not occur round the whole edge of the blastoderm simultaneously; the invagination takes place first beneath the embryonic rudiment, and the rest of the lip of the blastopore is not inflected till a late stage when the yolk cells are almost completely enveloped by epiblast. But ultimately the whole edge of the blastoderm is inflected, and thus in the Amphibian, as in the Teleostean, the yolk blastopore or aperture by which the yolk protrudes, coincides with the true primitive blastopore.

In the Elasmobranch ovum this is not the case. Only a proportionally small arc of the edge of the blastoderm is ever inflected, and the dorsal region of the embryo is entirely formed by concrescence out of this part of the blastoderm. As far as the evidence goes at present, the inflected part of the blastodermic rim extends when it is folded together as far as the neurenteric canal, and the aperture by which the yolk protrudes after the coalescence has reached this point is a hernia in the ventral wall of the body. Thus only the inflected arc of the edge of the blastoderm in the Elasmobranch is homologous with the whole lip of the blastopore in the ancestral gastrula, the rest of the edge corresponds to a rupture in the ventral wall of the body of the ancestor, or of the Teleostean embryo.

In the Sauropsidan blastoderm, no part of the edge is ever inflected, nor does the embryo ever extend to the edge of the blastoderm, as it does in Elasmobranchs and Teleosteans. In the median dorsal line of the Sauropsidan embryo there is a linear structure called the primitive streak divided into two parts by the neurenteric canal. Along the anterior part the hypoblast and epiblast are originally continuous; the posterior part belongs to the ventral surface of the body. The anterior part of the primitive streak represents the original blastopore, the posterior part, the coalescence of the non-inflected part of the edge of the blastoderm in Elasmobranchs. The edge of the blastoderm in Sauropsida corresponds to a new ventral hernia apparently not continuous with the hernia in Elasmobranchs represented by the posterior part of the primitive streak. Thus no part of the edge of the blastoderm is homologous with the lip of the ancestral blastopore, or with the edge of the blastoderm in Teleosteans or Amphibia, or with the edge of the blastoderm in Elasmobranchs.

The working out of these general views in detail will form an interesting subject for future researches in the comparative embryology of vertebrates. There is one point at present which is ripe for settlement, and that is, whether any part of the primitive blastopore extends in any vertebrate to the ventral side of the body. From the evidence of Teleostean development the answer to the question seems to be negative, but Sedgwick and Miss Johnson of Cambridge have brought forward some evidence that the posterior end of the blastopore in Triton gives rise to the permanent anus.

Monday, 4th May 1885.

JOHN MURRAY, Esq., Ph.D., Vice-President,
in the Chair.

At the request of the Council, an Address was given by R. T. Omond, Esq., on two years' Residence and Work at the Ben Nevis Observatory.

On the motion of the Chairman, a vote of thanks was accorded to Mr Omond for his Address.

The following Communication was read:—

On Detached Theorems on Circulants. By Thomas Muir, Esq., LL.D.

PRIVATE BUSINESS.

The following Candidates were balloted for and declared duly elected Fellows of the Society:—Johnson Symington, Esq., M.B.; J. F. Pullar, Esq.; Professor J. M. Dixon; and J. Macdonald Brown, Esq., M.B.

Monday, 18*th May* 1885.

EDWARD SANG, Esq., LL.D., Vice-President, in the Chair.

The following Communications were read:—

1. On the Hessian. By Professor Chrystal.

2. On the Distribution of Potential in a Thermo-Electric Circuit, open or closed. By Professor Tait.

3. On the Volume of Mixed Liquids. By R. Broom, Chemical Laboratory, Glasgow University. Communicated by J. T. Bottomley, Esq.

After seeing in the course of one of Sir W. Thomson's lectures an experiment showing the contraction which takes place when a solution of common salt is mixed with water, I resolved upon making a number of experiments with a view to noting the result of mixing various solutions.

I find that a number of experiments of a somewhat similar nature have been made by MM. Bussy and Buignet (*Compt. Rend.*, 59), Mr F. D. Brown (*Jour. Chem. Soc.*, 1881), and by Mr W. Nicol (*Jour. Chem. Soc.*, 1883). The first two of these papers deal with organic liquids, and Mr Nicol has noted the result of mixing various salt solutions, whereas the experiments I have made give the results of mixing salt solutions with water.

The apparatus which I used in my experiments consisted of a wide glass tube of convenient length, with a narrower tube attached to one end, and the whole tube was accurately graduated, and contained 262 c.c. up to a convenient point in the small tube. If equal volumes are to be experimented upon, 131 c.c. of the denser liquid are poured into the tube, and on this an equal quantity of the lighter liquid is poured, which can be done without any apparent mixing. The tube is now placed in a cylinder of cold water, and the liquid brought exactly to the 262 c.c. mark. The tube is then taken out, and after inverting till no farther streakiness is observed, is again placed in the cylinder of water, and as soon as the temperature has become the same as at the beginning of the experiment, the alteration in volume is noted.

The following are the results of experiments which I have made with solutions of some of the common salts saturated at 10° C., using equal volumes of the solutions and water:—

Water with equal vol. of sat. sol. of following salts.	Parts of anhyd. salt dissolved by 100 parts of water at 10° C.	Contraction when mixed.
KCl	31·97*	·325 per cent.
K_2SO_4	10·1	·082 „
KNO_3	20·77	·144 „
K_2CO_3	88·72	2·682 „
NaCl	35·75	·490 „
Na_2SO_4	8·04	·107 „
$NaNO_3$	84·3	·975 „
Na_2CO_3	16·66	·206 „
NH_4Cl	36·6	·273 „
$(NH_4)_2SO_4$	...	1·302 „
NH_4NO_3	185·	·772 „
$CaCl_2$	63·3	1·135 „
$BaCl_2$	33·3	·235 „
$MgSO_4$	30·5	·677 „
$ZnSO_4$	48·36	·835 „
$FeSO_4$	19·9	·327 „
$Al_2K_24SO_4$	4·99	·033 „
$CuSO_4$	20·92	·218 „
$Pb2NO_3$	48·3	·228 „

It will be observed that there is contraction in every case; in fact, the only inorganic solution that I have met with, which when mixed with water expands, is ammonium hydrate. When equal volumes of NH_4HO (sp. gr. ·880) and water are mixed, the total volume expands ·33 per cent.

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* The results in this column are from Storer's *Dictionary of Solubilities*, and are chiefly from the experiments of Gay-Lussac and Poggiale.

Sulphuric and nitric acids show the greatest amount of expansion, while hydrochloric acid, when mixed with water, neither expands nor contracts.

Monday, 1st June 1885.

ROBERT GRAY, Esq., Vice-President, in the Chair.

The following Communications were read:—

1. The Visual, Grating and Glass-Lens, Solar Spectrum, as observed in the Year 1884. By C. Piazzi Smyth, F.R.S.E., Astronomer-Royal for Scotland.

(*Abstract.*)

This paper is the outcome of 12 months' private spectroscope building, two months' observing therewith, and ten months' computing and graphical presenting of the observations. The result is a Solar Spectrum map, extending through so many as 60 double quarto plates, but capable of being arranged for the cheapest photolithographic reproduction, in a manner very easy to examine, convenient for reference, and yet at the same time affording at every point new and severe tests for its degree of accuracy.

This latter important feature has been chiefly obtained by exhibiting on each plate, vertically one under the other, and on the same large, clear scale, five successive and independent series of observations of the same Spectrum piece. *Two* of these several series are eclectic collections from the best Solar spectra hitherto published elsewhere; and *three*, are as many successive and perfectly distinct sets of observations by the Author, made during the summer of 1884 near Winchester. That city being chosen because it was both as far South as he could go within the limits of the British country; and be free at the same time from a most serious evil in the atmo-

sphere of the far larger, and still growing, historic city of Edinburgh; viz., the excessive quantity of coal-smoke now vitiating its atmosphere, and almost prohibiting any of the nicer observations of Practical and Physical Astronomy.

The *three* several Winchester spectra so taken, have been kept equally separate during all the following stages of computation, and even up to their very insertions into the final collective plate-forms. In the meantime the *two* eclectic spectra already mentioned, had been introduced in pen and ink on those plates for the Author, by Mr Thomas Heath, First Assistant Astronomer, R. Ob. Edin.; ensuring thus not only better draughtsmanship, but a still further degree of independence whenever a questionable case, whether of agreement or disagreement, should occur, between any of the 6, or 7,000 lines 5 times repeated.

Three, however, only of the five, sets, viz., the Author's three, appertain to the year 1884;—a period of well marked anomaly in the higher regions of the earth's atmosphere, as shown by the broad halo apparently around, or rather in front of, the Sun during the whole of that time,—a condition which is considered in the course of the paper.

2. On Knots. Part III. (Amphicheirals). By Prof. Tait.

3. On the Chemistry of Japanese Lacquer. By Hikorokuro Yoshida, Chemist to the Imperial Geological Survey of Japan. Communicated by Hugh Robert Mill, B.Sc.

The lacquer tree (*Rhus vernicifera*) is indigenous to Japan; it supplies a valuable timber, and its fruit yields vegetable wax, but it is chiefly cultivated on account of its juice—lacquer (*Urushi*)—which forms the basis of the famous Japanese varnishes. The juice is obtained by making incisions in the tree, and it is made into a varnish by simply stirring in the sun in order to drive off an excess of moisture. Different colours may be imparted to the varnish by the addition of various metals, oxides, and sulphides; and after it has been applied to an object it must be hardened by exposure to a moist atmosphere at a moderately high temperature.*

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* For particulars as to the preparation and use of lacquer, see the essay in *Forestry and Forest Products*, Edinburgh, 1885, p. 515, of the chemical part of which this paper is an abstract.

Specimens of lacquer juice for this research have been received from different parts of the country. That on which I worked was kindly supplied by Mr Magaribuchi from Yoshino. As this juice was originally intended for chemical investigation, and as it was collected in the best place in the Empire, under strict official inspection, it must have been in the purest form obtainable.

The pure juice is a thick greyish fluid of dextrinous consistency, which, under the microscope, is found to consist of minute globules, of darker or lighter colour, mixed with small particles of opaque brownish matter, the whole being held mixed in the form of an intimate emulsion. It has a characteristic sweetish odour. The specific gravity is 1·0020 (20° C.); but some specimens, such as that obtained from Hachiôji, contained bark, dust, and other impurities, which raised the specific gravity to 1·038. If the juice be exposed to the air in a thin layer at 20° C., it rapidly darkens in colour, and dries up to a lustrous translucent varnish.

Mr S. Ishimatsu (now S. Hiraga), in a paper on *Urushi*, which was written some years ago at Tokio University, and afterwards communicated to the Manchester Literary and Philosophical Society,* by Professor Roscoe (Feb. 18, 1879), has shown that the constituents of the juice are a resin, a gum, water, and a small residue insoluble in water or in alcohol. The method of separation which I employed was the same as that adopted by Mr Hiraga. A resinous acid (urushic acid), together with a small quantity of the volatile matter, is separated from the other substances of the juice by treating it with absolute alcohol, evaporating the solution, and drying the acid at 105° to 110° C. The residue is boiled for some time with water, and the extract evaporated on a water-bath until it acquires a constant weight. This gives the quantity of gum. The residue, from the water extract, consisting of a coagulated diastatic matter, with small quantities of insoluble colouring substances, is dried at 100° C., and weighed. The difference of the sum of the percentages from 100 gives the amount of water and volatile matter. Thus pure Yoshino lacquer was found to have the following composition :—

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* Memoirs, Manchester Literary and Philosophical Society, 3rd ser., vol. vii. p. 249.

	I.	
Part soluble in alcohol (urushic acid), . .	85·15	per cent.
Gum arabic, ... , ...	3·15	,,
Residue (nitrogenous matter), ...	2·28	,,
Water and volatile matter, ...	9·42	,,
	100·00	

The other unadulterated samples of the juice, some of which were analysed by Mr J. Takayama in our laboratory, had the following composition:—

	II. Hotta-mura Hitachi.	III. Sagami (southern district).	IV. Yechigo (northern district).	V. Hachiōji Sagami.	VI. Origin unknown. Bought at Tokio.	VII. Origin unknown. Bought at Tokio.
Urushic acid, . .	64·62	68·83	66·92	80·00	64·07	58·24
Gum arabic, . . .	5·56	5·02	4·75	4·69	6·05	6·32
Nitrogenous matter, .	2·10	2·01	1·72	3·31	3·43	2·27
Oil, ...	0·09	0·06	0·06	?	0·23	?
Water and volatile matter, . . .	27·63	24·08	26·55	12·00	26·22	33·17
	100·00	100·00	100·00	100·00	100·00	100·00

The juice which contains the largest amount of urushic acid is considered the best; in this respect No. I. Yoshino sample is superior to the rest, whilst VI. and VII. represent the average quality of the juice found in commerce.

I. *Examination of the alcoholic extract, Urushic Acid.*—This peculiar acid is the main constituent of the original juice, and also of the portion soluble in alcohol. The juice also contains a very small quantity of a volatile substance which passes into alcoholic solution, and is almost completely driven out during the drying of the acid at 105°–110° C.

Urushic acid is a pasty substance of somewhat dark colour, having the characteristic smell of the juice, readily soluble in benzene, ether, carbon bisulphide, and chloroform, less easily soluble in fusel oil and petroleum of high boiling point. It is quite insoluble in water. Its specific gravity, taken at 23° C., is 0·9851. The acid is not affected by a temperature of 160° C., but above 200° C. it decomposes slowly with carbonisation. When exposed to the air or in oxygen gas it neither dries up nor shows any sign of change as the original juice does, and in other respects it is a very stable body.

The acid, dried at 110° C., and analysed, gave the following results :—*

	I.	II.	Mean.	Theory for $C_{14}H_{18}O_2$ demands
Carbon, . . .	77·09	77·01	77·05	77·06
Hydrogen, . .	9·28	8·75	9·01	8·28
Oxygen, . . .	13·63	14·24	13·94	14·66
	100·00	100·00	100·00	100·00

The acid possesses very poisonous properties, and produces a most disagreeable itching sensation when applied to the skin. Although it does not act with equal severity upon all persons, the attack is worse when one comes in contact with it for the first time, subsequently the effect of the poison is very little felt. An immediate application of strong solution of acetate of lead to the inflamed part is the most effective remedy.

From the alcoholic solution of the acid many metallic salts can be produced, most of which are slightly soluble in alcohol, but almost insoluble in water.

Lead acetate gives a greyish flocculent precipitate — a very characteristic reaction of the acid. A quantity of this compound was prepared by precipitating an alcoholic solution of the acid with the lead salt. The precipitate, after being partially dried over a water-bath and in a dessicator, was analysed, and its composition found to be—

	Found.	Theory for $(C_{14}H_{17}O_2)_2Pb$ requires
Carbon, ...	52·08	52·40
Hydrogen, . . .	5·34	5·30
Oxygen, ...	10·13	10·01
Lead, ...	32·45	32·29
	100·00	100·00

This lead compound is a somewhat unstable body; when heated in an air-bath to 100° C. it gives off a peculiar odour, and turns darker in colour; at 110° to 115° C. it melts, and becomes a dark brown mass; at about 130° C. it ignites spontaneously in the air, burning with a smoky flame, and leaving an oxide of lead.

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* Analysed by Mr Hiraga.

Another salt of this acid which I examined was an iron compound. *Ferric chloride* gives a deep black voluminous precipitate, very slightly soluble in alcohol, and almost insoluble in water. Some of the alcoholic solution was precipitated with an insufficient amount of ferric chloride in order to see whether this fractional precipitation gave a salt of different composition. The compound obtained proved to be a salt of a very acid nature. Before analysis it was partially dried over a water-bath, and finally in a dessicator over sulphuric acid.

	I.	II.	Mean.	Theory requires for $(C_{14}H_{17}O_2)_3Fe$, $9(C_{14}H_{18}O_2) + 2H_2O$.
Carbon, . .	74·42	74·40	74·41	74·51
Hydrogen, . .	8·18	8·13	8·15	8·03
Iron, . . .	2·07	2·07	2·07	2·08
Oxygen, . .	15·33	15·40	15·37	15·38
	100·00	100·00	100·00	100·00

Another preparation of the iron salt was made with a larger quantity of ferric chloride than before. The compound again proved to be an acid salt, but of less complexity than the first. On analysis it gave the following result:—

	Found.	Theory for $(C_{14}H_{17}O_2)_3Fe$, $3(C_{14}H_{18}O_2)$ requires
Carbon, ...	74·56	74·06
Hydrogen, . . .	8·06	7·72
Iron, ...	4·29	4·11
Oxygen, ...	13·09	14·11
	100·00	100·00

These salts have very similar characteristics. They are light substances of a faint peculiar odour; at 120° C. they melt to a black mass with some decomposition, and at a somewhat higher temperature they ignite spontaneously, giving off dense smoke of a disagreeable odour. The *roiro* lacquer is produced by the formation of some of these iron compounds.

Experiments have shown that to prepare a good *roiro* lacquer, one must be careful to avoid adding too much iron salt to the juice;

for in that case the varnish will, in course of time, acquire a much browner shade (the oxidised iron urushiate having a reddish brown colour), losing at the same time in some measure its admirable qualities of resisting the action of strong chemical reagents. A small quantity of any soluble iron salt added to the juice will suffice for the preparation of the best roiro lacquer.

Free alkalies impart a very dark colour to the solution of urushic acid, which by transmitted light looks purplish blue, and by reflected light very dark brown. This viscid compound, if exposed to the air, rapidly blackens and dries up. It is a compound of an alkali metal with the acid, the normal salt of which will probably be represented by the formula $C_{14}H_{17}M'O_2$. The salt was not quite fit for analysis, as it seemed to suffer oxidation like some other salts of urushic acid during the processes of purification and drying.

Long-continued action of strong hydrochloric acid upon urushic acid produces a peculiar change in the latter; the resulting body has exactly the same composition as the original acid, but very different properties. When urushic acid was heated with a very large excess of hydrochloric acid for about three days, that lost by evaporation being replaced, it first swelled up to a soft sponge, gradually assumed a caoutchouc-like state, and finally hardened into a dark inadhesive mass. The substance, being cut into small pieces, was boiled with water, filtered, and dried over a water-bath till the last trace of hydrochloric acid retained in the pores of the substance was expelled. On cohobation with alcohol a small quantity of the substance dissolved, and this, when examined, showed the usual characteristics of unchanged urushic acid. The residue dried at 105° C., gave this result on analysis:—

	Found.	Mean obtained for Urushic Acid.
Carbon, . . .	77·07	77·05
Hydrogen, . .	8·77	9·01
Oxygen, . . .	14·16	13·94
	100·00	100·00

It appears from this that urushic acid suffers molecular transformation (polymerisation) under the influence of strong hydrochloric acid. β-urushic acid thus formed is a dark brownish solid body, with a faint peculiar odour, and soluble with difficulty in the usual solvents of urushic acid. Such being the case, an experiment was tried to ascertain whether urushic acid dries in an atmosphere charged with hydrochloric acid. A glass plate, very thinly coated with pure urushic acid, was placed upon a basin containing fuming hydrochloric acid under a bell jar, dried after standing two days. The urushic acid darkened in colour, and looked somewhat similar to the naturally hardened lacquer. When the β acid is heated to 100° C. it merely softens a little, and even at 130° it shows no sign of decomposition. It appears that the substance obtained by the decomposition of an alkali salt of urushic acid with hydrochloric acid is the same body as β-urushic acid.

Bromine acts powerfully upon urushic acid, evolving fumes of hydrobromic acid. To a solution of the acid in carbon bisulphide bromine was gradually added till it was in some excess; the whole being evaporated to dryness over a water-bath the mass was exhausted with strong alcohol, and the extract again evaporated, after which it yielded a dark semi-solid mass. This was tested for bromine by igniting it with pure lime. 0·7060 grammes of the substance gave 1·1510 grammes of silver bromide; or bromine was shown to be present in amount equal to 69·37 per cent., agreeing with a hexabromo substitution derivative of the acid, having the formula $C_{14}H_{12}Br_6O_2$, which requires 69·36 per cent. of bromine. At ordinary temperatures it is an almost solid body of a brownish colour, and soluble in most solvents of urushic acid. By using regulated quantities of bromine its lower substitution products might perhaps be obtained. Chlorine also gives a series of substitution products; but the compounds have not yet been fully examined.

The action of *nitric acid* upon urushic acid gives rise first to a series of nitro-substitution products, which appear to change afterwards into another acid containing more oxygen. The reaction is very energetic; the urushic acid first swells up to about thirty times its original bulk in the form of a yellowish sponge, which disappears gradually with the progress of the reaction. A quantity of this porous body was heated for half a day, treated with a large quantity of water, dissolved in alcohol, and precipitated with ferric chloride. The precipitate, after the usual purification and drying, was analysed, and the following results obtained:—

	Found.	Theory for $[C_{14}H_{15}(NO_2)_2O_2]_3Fe$ needs
Carbon, . . .	51·49	51·59
Hydrogen, . .	4·82	4·61
NO_2, . . .	28·16	28·25
Iron, . . .	9·77	9·81
Oxygen, . . .	5·76	5·74
	100·00	100·00

This is the ferric salt of *di-nitro-urushic acid.* The acid itself is a bright yellowish solid, readily soluble in the usual solvents of urushic acid, and gives characteristic reactions with many metallic salts: those of silver, lead, zinc, and manganese are light yellowish precipitates; those of copper and iron, greenish yellow; and those of soda and potash, light brownish. The acid itself and its metallic salts are to some extent soluble in water, and more so in alcohol. The higher nitro-substitution products, are likewise yellowish substances; their salts also seem to be characterised by their greater solubility in water and alcohol.

When the action of nitric acid upon the yellowish substance is continued for several days, it finally goes into solution with copious evolution of nitrous fumes. On evaporating the solution over a water-bath, and cooling it, a large number of small granular crystals are formed. The mother liquor, when treated with more of the strong nitric acid and evaporated, yielded several crops of similar crystals. These crystals were mixed, cleaned from the small quantity of brownish oily matter, and recrystallised from ether several times until quite pure. On analysis the following result was obtained:—

	I.	II.	III.	Mean.	Required by theory for $C_{13}H_{22}O_8$.
Carbon, . . .	50·96	50·82	51·01	50·93	50·98
Hydrogen, . .	7·13	7·20	7·22	7·18	7·19
Oxygen, . . .	41·91	41·98	41·77	41·89	41·83
	100·00	100·00	100·00	100·00	100·00

The substance is an acid which contains no nitrogen, and no water of crystallisation. At 134° C. it melts without decomposition to a yellowish liquid, and at 126° C. solidifies in a capillary tube.

It is readily soluble in alcohol and water, and less easily in ether. Its iron and lead salts are yellowish crystalline precipitates; that of barium of straw yellow, and of silver white. They are all slightly soluble in water. The alkali and calcium salts, which are also light yellow, are readily soluble in water and in alcohol. A quantity of the silver salt was prepared by decomposing silver acetate with aqueous solution of the acid. The ensuing precipitate was analysed with the following result:—

	I.	II.	Mean.	Theory for $C_{13}H_{18}Ag_4O_8$ needs
Carbon, . . .	21·20	21·19	21·20	21·25
Hydrogen, . .	2·39	2·59	2·49	2·45
Silver, . . .	58·86	58·86	58·86	58·85
Oxygen, . . .	17·55	17·36	17·45	17·45
	100·00	100·00	100·00	100·00

This silver salt suffers partial decomposition, blackening when exposed to sunlight. The barium salt of this acid was also prepared by exactly neutralising its aqueous solution with barium carbonate. The solution was evaporated to dryness, and the substance obtained analysed. By carefully and slowly evaporating the aqueous solution of either the silver or the barium salt, the substance can be got in minute hard crystals.

	Found.	Theory for $C_{13}H_{18}Ba_2O_8$ requires
Carbon, ...	27·02	27·08
Hydrogen, ...	3·09	3·13
Barium, ...	47·60	47·57
Oxygen, ...	22·29	22·22
	100·00	100·00

From the analyses of its salts the acid is evidently a new one, and tetrabasic, being represented by the formula $C_9H_{18}(COOH)_4$; but no name has yet been given to it.

The distillation of urushic acid with lime gives a small quantity of light hydrocarbon, which, however, appears to polymerise very easily during its purification by fractional distillation. The nature of this oil is being examined; but one of the lighter fractions analysed gave numbers which indicate a composition approaching that represented by $C_{14}H_{24}$, showing it to be probably one of the higher hydrocarbons of the terpene series. It absorbs oxygen from the air, and forms a resinous mass. It unites readily with bromine, and is blackened by concentrated sulphuric acid in the cold.

II. *Examination of the water extract, the Gum.*—Gum is a normal constituent of lacquer juice, and forms from 3 to 8 per cent. of the original liquid. Since gum is insoluble in alcohol, it is conveniently separated by treating that portion of the original which was insoluble in alcohol with boiling water, filtering, and evaporating on a water-bath till the weight becomes constant. In this way a friable, light-coloured, tasteless and inodorous substance is obtained. This is the anhydrous gum. On combustion it gave the following numbers:—0·5267 grammes of the substance gave 0·7823 grammes of carbonic acid (CO_2), 0·2834 grammes water (H_2O), and 0·0267 grammes ash. Analysis of the ash in a separate sample of the substance gave the following:—

Silica (SiO_2), ...	0·48	
Lime (CaO), ...	44·77	
Potash (K_2O), ...	13·68	
Iron oxide, ...	trace.	
Alumina (Al_2O_3), ...	7·85	
Magnesia (MgO), ...	5·79	
Soda (Na_2O), ...	1·33	
Carbonic acid (CO_2), ...	26·10	by difference.
	100·00	

If the metals in the ash be replaced by the equivalent amount of hydrogen, and the result calculated for carbon, hydrogen, and oxygen, the result will be—

	Found.	Arabic acid $C_{12}H_{22}O_{11}$.
Carbon, ...	42·47	42·11
Hydrogen, ...	6·40	6·43
Oxygen, ...	51·13	51·46
	100·00	100·00

The gum, when inverted, has the power of reducing Fehling's solution. 0·4747 grammes of the substance (ash deducted), after inversion with 10 per cent. hydrochloric acid, and precipitated, gave 0·8114 grammes of cupric oxide. If we suppose that after the hydration, one molecule of arabic acid ($C_{12}H_{22}O_{11}$) changes into two molecules of sugar ($C_6H_{12}O_6$), the molecular ratio which the product of inversion bears to cupric oxide will be exactly two-thirds of that of dextrose to cupric oxide, and consequently its cupric oxide reducing power or K will be 75. This, however, requires further confirmation. But whatever may be the nature of the sugar which is produced from this gum, its physical properties are identical with those of gum arabic. It is present in urushi juice in the form of an acid salt (probably of arabic acid), in combination chiefly with potash, lime, alumina and magnesia; and the point of difference which is of interest is the presence of an alumina salt, which has not hitherto been observed in other gums. A mixture of the gum and urushic acid with water in the proportion in which they exist in the juice *does not undergo any change* even when exposed to the conditions most favourable for the drying of the lacquer. Moreover, part of the gum can be extracted in an unchanged state from the perfectly hardened lacquer, and since it exists in the original juice in the form of aqueous solution, it probably serves to keep the constituents of the juice in a state of uniform distribution and intimate emulsion. It may also act as a binding material, and assist the adhering power of the lacquer when laid on any surface.

III. *The Nitrogenous Matter and its action upon Urushic Acid.*—That portion of the juice which remains insoluble in alcohol and boiling water consists essentially of a nitrogenous matter, the action of which upon urushic acid is the cause of the hardening of the lacquer. It forms from 2 to 8 per cent. of the original juice. The juice which contains most of it dries most quickly, but gives a varnish of inferior lustre. The substance, separated from the gum by the usual method of boiling water, has no action upon urushic acid, but the residue (after the separation of urushic acid) or its extract with cold water, shows its peculiar diastatic activity in an unimpaired degree. When such a solution is boiled, the albuminoid matter coagulates in the form of a white precipitate.

The substance, first dried on a water-bath, and then over sulphuric acid, gave on analysis, the following numbers :—

	I.	II.	Mean.
Carbon, . . .	59·52	59·72	59·62
Hydrogen, . . .	7·62	lost.	7·62
Nitrogen, . . .	5·48	...	5·48
Oxygen, . . .	26·18	...	26·08
Ash, ...	1·20	...	1·20
	100·00		100·00

In the ash traces of sulphur and phosphorus were detected.

The substance is slightly soluble in water, 10 per cent. sodium chloride solution, and in weak alkali solutions; but other liquids seem to have no solvent action upon it. It has no perceptible action upon sugar solution or gelatinised starch. It differs from the other albuminoids in containing a notably smaller amount of nitrogen (only one-third), whilst the numbers obtained for carbon, hydrogen, and oxygen for its composition very nearly agree with those of the other albuminoids. Active principles of malt (diastase), koji, and saliva do not possess the same property of exerting the peculiar action above mentioned upon urushic acid.

Two series of experiments were instituted to test the activity of the nitrogenous matter upon urushic acid, first at different temperatures, and secondly in different gaseous media. For this purpose a small quantity of Yoshino juice was put into a covered beaker and subjected to the regulated heat of the water-bath, the water lost by evaporation being replaced. The heated juice was next thinly coated on a glass plate, and left to dry in a box, the air of which was kept constantly moist by the falling in of drops of water. The time of heating in each experiment was from three and a half to four hours, and the temperature of the drying-box was 20° C.

1. At ordinary temperatures (20° C.) the sample dried after 3½ hours in air, and the same under a bell jar containing moist oxygen gas dried after less than 2 hours.
2. The juice heated to 30° C., sample dried after 4 hours.
3. „ „ 40°–43° C., „ „ 4½ „
4. „ „ 50° C., „ time not known.
5. „ „ 55°–59° C., „ after 24 hours;

The surface of the lacquer had a dull appearance.

6. The juice heated to 60°–63° C., sample did not dry.
7. „ „ 80° C., „ „
8. „ „ 100° C., „ „

Mr J. Takayama, working very carefully on a sample bought at Tokio, found the limit of activity of nitrogenous matter to be 70°–73° C., but with the Yoshino sample (which contains much less nitrogenous matter and water) he confirmed my former number of 60° C. as the limit. His method was to place the juice in a boat in a tube immersed in gradually heated water.

Next, glass plates coated with urushi juice were put under a bell jar containing an experimental gas, and left to dry at the temperature of the air, ranging between 13° and 15° C.

1. In dry air the sample did not dry.
2. „ moist „ „ dried after 4 hours.
3. „ dry oxygen „ did not dry.
4. „ moist „ „ dried after 2½ hours.
5. „ dry hydrogen „ did not dry.
6. „ moist „ „ dried imperfectly after 1½ day.
7. „ dry carbonic acid the sample did not dry.
8. „ moist „ „ dried very slowly after 2 days.
9. „ dry nitrogen „ did not dry.
10. „ moist „ „ dried imperfectly after 1½ day.

The most legitimate inference to be drawn from all these experiments is that the combination of oxygen and moisture at the temperature of 20° C. is an essential condition for the display of the fullest activity of the diastatic matter, and consequently most favourable for the drying of the lacquer. With either the increase or decrease of temperature, the drying power decreases; at 0° to 2° C. it is temporarily suspended, and at from 60° to 70° C., the substance entirely loses its activity; this is then the point at which the coagulation of the albuminoid matter takes place—or, in other words, the diastatic action ceases. With other gases, however, I am inclined to think that some atmospheric air, which may have been present in them, might have favoured the conditions for drying; otherwise it would not have been possible. Mr J. Takayama has recently confirmed the view that lacquer juice never dries in an atmosphere of hydrogen or of carbonic acid, when kept in a eudiometer standing over mercury. These conclusions bear out the practical experiences of our lacquer men, viz., that lacquer dries most readily in the rainy season, and better in summer than in winter—a damp atmosphere at a temperature of 20° to 30° C. being usual during the rainy season.

The nitrogenous matter in the juice, if it be really possessed of a peculiar kind of diastatic action upon urushic acid, ought to be able to cause the change upon a comparatively large quantity of the acid. To study this property, and to find out the limit of the quantity of that substance within which the action can still take place upon the acid, certain experiments were made. Various mixtures of a known quantity of Hachioji juice with a weighed quantity of pure urushic acid were made; after each mixture had received the requisite quantity of water, it was thoroughly mixed in a mortar, and left to dry in a thin layer on glass plates in a moist chamber.

The practical limit within which the action can take place was found to be 1 of the nitrogenous matter to 413 of urushic acid.

Although a much less quantity of the diastatic matter can effect the drying of the acid after the lapse of many days, such length of time will unquestionably be considered inconvenient in practical working with the juice as a varnish. These experiments also show that the amount of gum in the juice can be brought down to a small percentage without bad effect. A large quantity of it, as it exists in bad juice, is always injurious, as it produces blisters upon the newly lacquered ware when it is brought into contact with water for any length of time. Knowing these facts, we are now able to prepare any good quality of the juice for varnish making, by mixing a regulated quantity of pure urushic acid with the natural juice.

The question still remains, How does the diastase act upon the urushic acid, or what is the change which urushic acid undergoes in drying? To solve this question, the states of the lacquer before and after drying have been examined and compared.

A quantity of the fresh juice (Yoshino sample) was rapidly heated on a water-bath, so as to coagulate the albuminoid, and put a stop to its further action upon the urushic acid. The heat was continued till all the water was expelled from the juice; the substance was then analysed, with the following result :—

	I.	II.	Mean.	Numbers calculated from the constituents of the juice.
Carbon, . . .	75·47	75·61	75·54	75·54
Hydrogen, . .	8·93	9·01	8·97	9·14
Nitrogen, . .	0·11	...	0·11	0·10
Ash, . . .	0·21	...	0·21	0·21
Oxygen, . . .	15·28	...	15·17	15·01
	100·00		100·00	100·00

The lacquer dried (naturally hardened) in the usual manner, and afterwards heated at 100° C. had the following composition:—

	I.	II.	Mean.
Carbon, ...	70·90	70·84	70·87
Hydrogen, . . .	8·55	7·90	8·225
Nitrogen, . . .	0·092	...	0·092
Ash, ...	0·032	...	0·032
Oxygen, ...	20·426	...	20·781
	100·000		100·000

The comparison of these two results indicates that the lacquer in hardening had taken up oxygen; and we see that, *cœteris paribus*, the amount of oxygen thus taken up is almost quite accounted for on the supposition that each molecule of urushic acid ($C_{14}H_{18}O_2$) in the juice has taken up one atom of oxygen, and changed into another body, $C_{14}H_{18}O_3$.

Further proof of this theory has been reached by the preparation of *oxy-urushic acid* ($C_{14}H_{18}O_3$), *which showed all the properties of a dried lacquer.* Urushic acid was repeatedly subjected to the action of strong chromic acid mixture containing some excess of sulphuric acid to prevent the precipitation of chromic oxide. The product, cohobated with strong alcohol to dissolve away the unattacked urushic acid, gave, on drying at 106° C., a brownish powder of the following composition:—

	First Preparation.		Second Preparation.	
	I.	II.	I.	II.
Carbon,	71·55	71·50	71·69	71·71
Hydrogen,	8·32	8·13	7·60	7·72
Oxygen,	20·13	20·37	20·71	20·57
	100·00	100·00	100·00	100·00

	Mean.	Theory for $C_{14}H_{18}O_3$ requires
Carbon,	71·61	71·79
Hydrogen,	7·94	7·69
Oxygen,	20·45	20·52
	100·00	100·00

This substance is very stable, and resists the action of strong mineral acids except hot fuming nitric acid, which gradually changes it to a yellowish body, and finally into the new acid previously mentioned, $C_9H_{18}(COOH)_4$. No solvent has yet been found for it. *The strength and durability of lacquer varnish are due to the presence of this oxy-urushic acid.* Many experiments on the hardening of lacquer were made by Mr J. Takayama, and they conclusively establish the fact that hardening is due to the oxidation of urushic acid, and not to its hydration.

Some drying oil is frequently added to the lacquer juice to make varnish. I have studied this point, to learn how far the introduction of the oil is admissible, without impairing the essential quality of the lacquer. It is ascertained that the addition of 10 to 15 per cent. of the drying oil to the juice does not hinder the hardening power of the lacquer, and 20 or 25 per cent. of the oil can be introduced without much bad effect. Such a mixture gives a varnish of greater transparency and spreading power than the pure juice itself, but its capability of withstanding strong chemical reagents is proportionally reduced. The results arrived at may be summoned up in the following statements :—

1. Lacquer juice consists essentially of four substances, viz., urushic acid, gum, water, and nitrogenous matter.

2. The main constituent, urushic acid, is a stable acid, capable of forming many well-defined salts and derivative compounds.

3. The gum is probably identical with gum arabic.

4. The nitrogenous matter has a composition allied to albumen, with much less nitrogen, and has a peculiar diastatic property.

5. The hardening of the juice is due to the oxidation of urushic acid ($C_{14}H_{18}O_2$) into oxy-urushic acid ($C_{14}H_{18}O_3$), which is effected by the aid of the nitrogenous matter in presence of oxygen and moisture.

6. The hardening can only take place within narrow limits of temperature, viz., between 0° to 2° C., on one side, and the temperature of the coagulation of the albuminoid (60° to 70° C.) on the other.

7. The gum is essential in keeping up the emulsion and uniform distribution of the constituents; but in the hardened lacquer it is injurious, causing blisters on newly lacquered ware when treated with water for a length of time.

8. Any quality can be conveniently given to the juice by the addition of pure urushic acid, which brings down the relative amounts of gum and nitrogenous matter. The lacquer becomes thus more transparent and gains in strength.

9. The mixture of 20 to 25 per cent. of drying oil with the juice does not much impair the essential quality of the lacquer.

4. On Atmospheric Electricity at Dodabetta. By Professor C. Michie Smith.

5. Recent Photographs of Stars, described by C. Piazzi Smyth, Astronomer-Royal for Scotland.

For many years past some little amount of isolated work *has* occasionally been accomplished in photographing certain of the brighter stars. But lately, stellar photography has gone forward with leaps and bounds; so that at a dozen different Observatories in Europe, America, South Africa, and Australia, so much is now being done in that line, that there is a speedy prospect of, in a manner, the whole sidereal heavens being photographed, and after a fashion that would not only have astonished Hipparchus, but been equally surprising to either Sir William Herschel, or Argelander or Struve up to within a very few years ago.

The reason of this sudden development of astronomical photography is twofold. *First*, a remarkable improvement, amounting even to a bursting of its bonds of the previous quarter of a century, which has taken place in ordinary photography; and *second*, the accompanying circumstance, that those new methods have been found most peculiarly suited to the special requirements of the Astronomer.

The new Photography of the portrait gallery consists in the replacement of inflammable collodions, the silver bath, with all its sicknesses, wet films, soft, slippery, contractile and perishable, together with sensitizations which each worker had to prepare painfully to his own hand, each time of using;—their entire replacement by dry plates, prepared by the thousand at large manufactories, ready to any one's hand, and with their bromo-iodised hard gelatine films, far more sensitive than the best wet collodion of the old silver bath preparation.

Now, this enormous improvement has suited the astronomers in several ways. They were never very fond of dealing with alcohol and ether at night, or manipulating all the other dangerous, or delicate and difficult experiments of chemical laboratories in the confined space of their revolving domes. And if they did occasionally prepare "wet-plates," they had to use them immediately, or lose them; while if the sky happily remained clear enough for the using,—the wet-plate would not remain long in its highest state of sensitiveness, or cleanliness either; for certain "oyster-shell" markings, as well as "fogging," would begin to form upon it, pin-holes would multiply, and the image of a brilliant and minute point of light would begin to spread chemically in the film, until pungent star-points became, as to size, more like apples and oranges.

But the new dry plates, after very easy purchase, can be kept waiting for an opportunity, through any length of time. They admit also of any length of exposure, without losing their sensitiveness, and without spreading the images of bright points so extravagantly as the wet films. And this ability of the dry-plates generally to stand long exposures is simply invaluable in photographing faint stars; for, contrary to the human eye, which can either see such an object at once, or never (for longer looking merely fatigues the eye, and at last deprives it of all power)—the photographic dry-plate goes on accumulating the effects of an at first invisible star, until by such accumulation a visible, or rather developable, mark is at length made; and if 5 minutes are not enough to produce that effect, a ¼ hour, ½ hour, or even a whole hour may be tried.

To compass such an interval, the clock-work movement of any equatorial must of course be particularly good, and sedulously watched to keep the star-images always on one spot, and prevent their being drawn out into ellipses. But this correction being applied, then the only chemical operation left with the astronomer, is the developing of the latent image on the plate; which operation, however, may be delayed with these new plates to next day, or week, or month even, if agreeable.

Now the special examples of this new stellar photography which I have to lay before the meeting,—have been kindly sent to me by my friend Dr David Gill, Astronomer-Royal at the Cape of Good Hope: and as he is not present here, but is now on the other side of the world, I need have no compunction about alluding to him as a new rising star, of the first magnitude and richest promise, appearing just now above the Astronomical horizon; and by his singular genius, and surpassing success in whatever he undertakes, doing as much honour to his native city, the Granite Queen of the North, as to the Tercentenary of the Edinburgh University, where he received an Honorary Degree last year.

A professional photographer, with abundant supplies of apparatus and materials, was recently sent out to him, to act under his directions; and he has now accordingly begun, with that aid, the regular and systematic mapping of the whole Southern Sidereal heavens, seven degrees by seven degrees at a time; and the examples he has just sent, are merely the first essays. Yet they possess already a very considerable degree of perfection; and are specially to be commended for the neatness and roundness of all their stellar discs,—the long exposures notwithstanding.

The 1st of these interesting photographs represents, in chief, the three notable stars forming the belt of Orion, on a scale of 1 inch to 1 degree, and with an exposure of half an hour.

The 2nd represents the same subject, but with an exposure of one hour; and a great increase will be remarked in the number of smaller and exceedingly minute stars.

The 3rd represents, on the same scale though with a larger field, part of the Milky Way near that remarkable variable η Argûs.

While the 4th shows the instrument with which the views were obtained.

These photographs are evidently sharp enough to admit of being magnified several times linear, rendering the smaller stars more easily visible. Doubtless therefore, Dr Gill, who does everything well and on a continually rising ideal, will eventually have them magnified to that degree, or perhaps more; and will make his Camera views of the stars, everything that such short focussed views can ever become.

But I should warn the meeting that they never can rise up to the extraordinary importance of supplanting all the older forms of astronomy, as has been recently bruited about, with so much confidence, by some very well-intentioned persons; but who are not practically acquainted with either the *excelsior* requirements of intellectual astronomy on one side, or the limited capabilities of a photographic film, on the other.

As the art-science now stands, and with the class of instrument used on this occasion,—exceedingly pretty, *integrating* views of what can be seen, on a very small scale, of the really unfathomable depths of the starry heavens, may be obtained, and will have their own particular uses and approximate applications. But any one of these mere Camera views is totally unable to *differentiate* to the terrible extent required by the higher astronomy of the present day.

In double-star work for instance, and its most important attribute of being able to demonstrate a physical connection between one star and another, amenable to the calculations of Newtonian gravitational astronomy,—we ought to be enabled to divide a second of space into several parts with certainty. And for that purpose, such portion of space should be represented on a photograph by not less than $\frac{1}{50}$ of an inch. But that implies, in this case, a further magnifying of not less than 70 times linear. Or the making, out of one of the photographs on the table, 4900 others, each as large as itself, to represent properly that one very small portion of the sky. So that an atlas, to show the whole sky on the same scale, would require about 5 millions of them; and by no means every photograph that is taken is always a success, and worthy of being kept; while every one that is kept requires at least two companions as good as itself, to guard against accidental imitations of little stars by either pin-holes in the film, or specks in the glass plate.

And even if we should replace *that kind* of magnifying by the Achromatic compound microscope,—we are just as badly subject as ever to the inherent weakness of an originally small photograph, as distinguished from Nature herself further magnified, in this important truth; viz., that we do not, by simply magnifying a discoloured film, separate close stars; we merely enlarge their discs, or discous impressions. And at the rate of enlarging already indicated, such disc, or spurious photographic effect, in the case of any one of these three stars in the Belt of Orion,—would swell out into a huge circle, no less than 3·5 inches in diameter! Utterly covering, concealing, or swallowing up therefore any interesting stellar companion such star might have, though it should be 800 times as far off as the small angular distances which astronomers have to deal with.

While further still, though long exposure may bring out more stars than short exposure, with the same instrument,—it does not by any means enable a small telescope to compete with a large one in what *it* can show with any exposure. Photography of the stars therefore, though begun most meritoriously with small instruments, will have to be continued afterwards, in the accustomed ways of old, with larger ones. Larger ones possessing more light, and more magnifying power;—but with the inevitable accompaniment of smaller angular fields of view; and in that case there will ensue a great multiplication of the sensitive plates required. Wherefore in place of the telescopes of the future being, by photography, reduced to pocket size and minimum cost,—they will rather have to be made larger than ever, and worked more expensively.

Hence it is that so able a practical astronomer as Mr Ainslie Common, who has been performing such wonders of astronomical photography with his grand reflecting telescope of 3 feet diameter of aperture, is casting about now for the erection of another telescope of 7 or 8 feet in diameter, or considerably larger than Lord

Rosse's; infinitely more refined in its mounting, and requiring an almost uncountable number of photographic plates to represent everything it is capable of showing throughout the sky.

By all means too, I would say, let him be furnished with such an instrument by any one who can afford it, for he will use it to excellent purpose, and it will be a noble monument of Great Britain; —but do not insist on getting from Dr Gill, the work of so colossal an instrument, when you have only furnished him with a rather large Camera, of the portrait-taking order.

The next and final photograph I have to show, was received lately from my friend Colonel A. T. Fraser, R.E., in charge of the public works at Trichinopoly, south of Madras.

Though at first sight having nothing astronomical about it, it is surely, as he himself says by letter,—

"A very remarkable photograph. It represents an immense, an almost countless collection of natives at Combaconam in the Tanjore District, on the river Cauvery; where, *once in every* 12 *years* the Ganges of the North of India is said to flow into and fill a certain built tank in the town.

"For that day, the 28th of February on this particular 12 year occasion of 1885, the Ganges itself loses its efficacy, and bathing in this tank is equally meritorious. Consequently vast numbers save a long journey, and avail themselves of the opportunity. And yet it is well known that the supply of the tank percolates from the Cauvery River close by.

"Now why should I say that this photograph will be specially interesting to you?

"I asked a Brahmin, who in private tells me things now and then, what occasions the gathering? He replied it was the rising of the star 'Mukkum,' in Sanscrit, that brought such crowds on that particular day, and the rising only happens once in 12 years.

"So here you have hundreds of thousands of natives assembled to bathe in a tank in an out-of-the-way town, in consequence of the star 'Mukkum' having a peculiar position, that probably hardly any of them could define; nor could in fact any of the crowd give an intelligible reason for being in the picture, except a few from curiosity or obligation.

"I cannot, not having references at hand, find out what star is meant. According to Bentley, both the Ganges and the Euphrates symbolise the Ecliptic in Esoteric Astronomy.

"But apart from this, look at the photograph and see how closely it tallies with Isaiah xviii., literally translated,—'A people scattered and bald to a nation to be feared from this and onwards; people corded.' The people in the photograph have put aside their turbans for fear of losing them, and you see nearly every head is shorn and bald; and you may be able to make out the Brahmins by the piece of pack-thread slung across their shoulder and chest.

"Combaconam is an obscure town, principally inhabited by Brahmins, who are largely pensioned officials. It contains, however, a College at which the highest English education is given, and where the late Sir Alexander Grant was once Principal.

"What star I wonder is this Mukkum," continues the Colonel, "and why should it be important enough to draw such a mass of Hindoos on the 28th of February to N. Lat. 10° 45′, and East Longitude 79° 30′. Is not a multitude that can be incited by a motive of which we have no appreciation, literally 'to be feared.'

"It may be admitted that our Madras Astronomer, Mr Pogson, is as learned an Astronomer as any of the day, and yet I am certain there is nothing he could say about any one of the stars, which could collect hundreds of thousands of men to bathe at an obscure town on the Railway. Therefore natives must know what we do not."

In a subsequent letter dated May 4, the Colonel further writes:—

"I am now able to give you some information about the stars fixing the festival at Combaconam, having got a Brahmin the night before last to actually point them out.

"It appears that 'Mukkum,' which means they tell me in Sanscrit 'sacrifice,' is not a single star, but the four stars together, in the sign Leo, forming the four corners of a rhomboid. They were just overhead here about 7^h P.M.

"The very bright star close to them, I was told was 'Bramahaspiti,' the 'tutor of Brahma'—though I identify it with the Planet Jupiter.

"Each sacred town has what is termed its 'Stalla Purana, or Purana loci, and the festival of which I sent you the Panorama is described in one of these,—some cure having occurred from bathing, when the stars 'Mukkum' rose at some epochal date near 10^{h} A.M., and at the same instant Jupiter entered Leo.

"These Puranas have seldom been translated, and the authoritative copies, as of all the Hindoo books, are graven on slips of Palm leaf. The importance of what can be written, or found written, on Palm leaves is shown by the Photograph."

So far this most interesting letter writer, Colonel Fraser.

Having now looked into the *Nautical Almanac* on his day of the Photograph being taken, viz., February 28, 1885, there is this close approach of Jupiter to α Leonis, viz.:—

H. M. S. ° ′
Jupiter R.A. = 10 8 59 and N. Decl. + 12 46
α Leonis R.A. = 10 2 15 and N. Decl. + 12 32.

While 12 years and a few days previously, viz., on January 19, 1873, the positions were, after Jupiter had in the meantime wandered through the whole breadth of the heavens—

H. M. S. ° ′
Jupiter R.A. 10 8 43 and N. Decl. = + 12 38
α Leonis — 10 1 37 and N. Decl. = + 12 35.

I shall inquire therefore of the Colonel what may have been the month and the day of the Festival being held in 1873, as well as at any other 12 year periods of which he can obtain exact information.

PRIVATE BUSINESS.

The following Candidates were balloted for, and declared duly elected Fellows of the Society:—Professor D'Arcy W. Thomson; Mr A. Y. Fraser; and Mr Alexander Scott.

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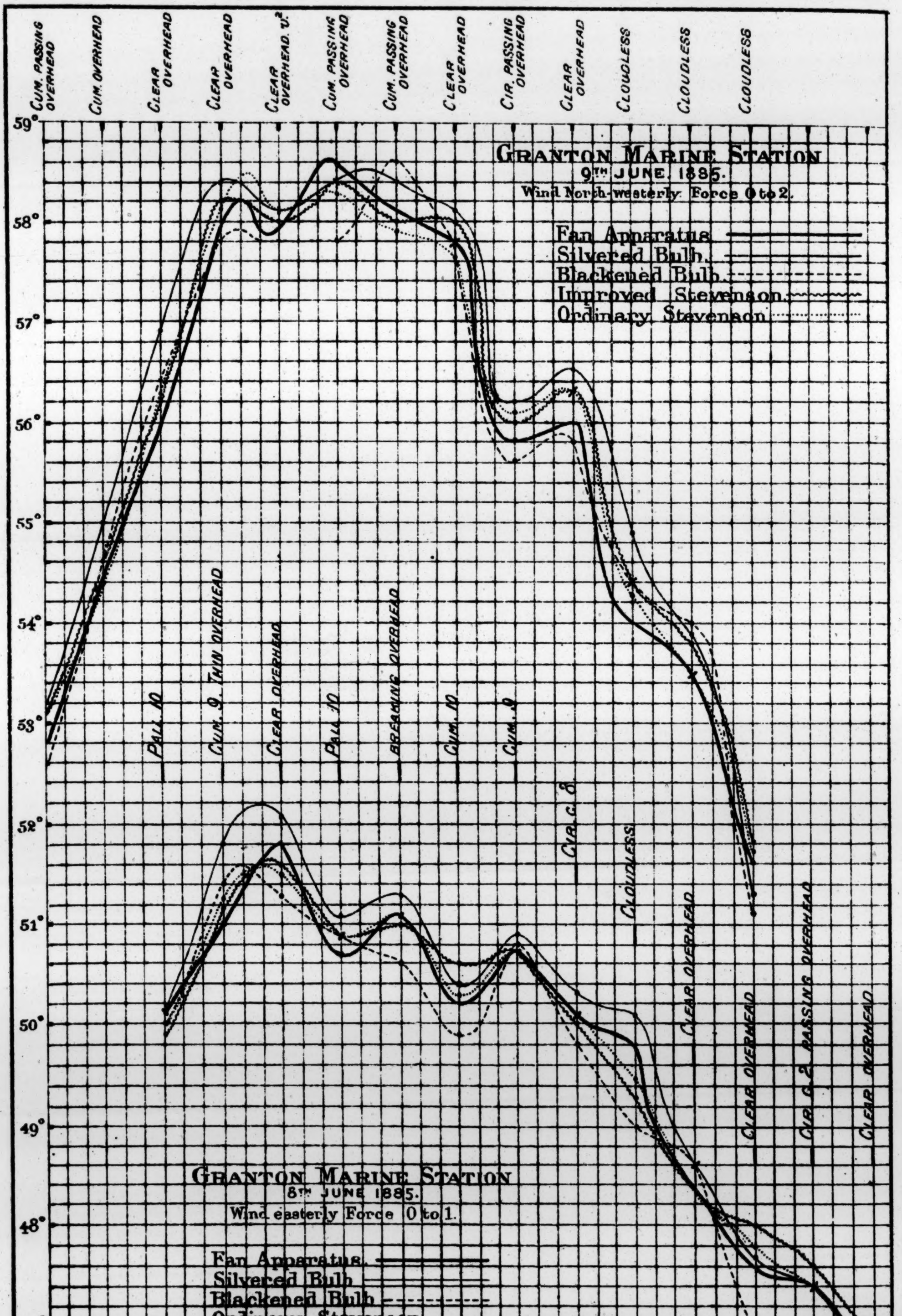

McFarlane & Erskine, Lithrs Edinr

Monday, 15th June 1885.

ROBERT GRAY, Esq., Vice-President, in the Chair.

The following Communications were read:—

1. On Theories of the Formation of Coral Atolls and Barrier Reefs. By John Murray, Ph.D.

2. Observations on Recent Calcareous Formations of the Solomon Group, and their bearing on the Theory of Formation of Coral Islands. By H. B. Guppy, M.D., R.N. Communicated by John Murray, Ph.D.

3. Observations, Morphological and Physiological, on Pitchered Insectivorous Plants. By J. M. Macfarlane, D.Sc.

4. Preliminary Note on Observations with Aitken's Thermometer Screens. By H. N. Dickson, Esq. (Plate VIII.)

The following results of observations made with four of the thermometer screens, devised by Mr Aitken of Darroch, form the commencement of an investigation which has been begun at Granton Marine Station, and which is to be carried on there and at Ben Nevis Observatory during the summer and autumn, with the view of finding a more suitable screen for exposing thermometers for meteorological purposes, and, if possible, of determining the mean correction to be applied to the readings of thermometers exposed in the ordinary Stevenson screens. So far, the work has been entirely of a preliminary character, but some points have been brought to light which are of considerable interest.

Mr Aitken's screens were described in a paper read before the Society, on 2nd June last year, and published in the *Proceedings*, vol. xii. p. 661.

The screen used as a standard with which to compare the others consists of a rectangular wooden tube, into which the bulbs of two thermometers—wet and dry—are inserted from above, and through which a current of air is made to circulate by means of a suction fan. The air drawn in by the fan does not come into contact with much heated surface, and the circulation is sufficiently rapid to keep the walls of the tube at the temperature of the air, and to absorb any heat the thermometers may receive by radiation, without being so strong as to generate heat by friction.

The readings of this apparatus have been compared with those given by the ordinary Stevenson screen, and an improved form, having a double top, and the bottom closed with louvre-boards of the ordinary pattern. Besides these, the readings of thermometers without screens, simply protected from direct sunshine, have been taken. One of these has its bulb enclosed in a silver thimble, which reflects diffused radiations of all kinds. Under another shade two ordinary thermometers are placed side by side—the bulb of one of them having part of its surface blackened. The blackened bulb, of course, absorbs part of the heat radiated to it, and the arrangement is so constructed that the excess of the reading of the blackened bulb above that of the clean bulb, subtracted from the reading of the clean bulb, gives the true air-temperature.

The curves shown are drawn from hourly observations taken during twelve hours daily. Since the commencement of these observations the weather has not been of the character required to put the various screens to a severe test, there having been always more or less wind. The actual differences of temperature given, are therefore not nearly so great as those observed by Mr Aitken under more favourable conditions last summer; but the differences that do exist are of considerable interest.

The positions of the curves relatively to one another evidently depend to a very great extent on the state of the atmosphere with regard to cloud, and the influence of the clouds is regulated, not so much by their amount as by their position—the effect of a small amount of cumulus cloud situated directly above the instruments being very marked.

In the forenoon, as the temperature rises towards the daily maximum, the curves for the two Stevenson boxes are steeper than that for the fan apparatus; starting sometimes from a point below it, and after crossing it, gradually increasing their distance. This is obviously due to the gradual heating of the boxes, the effect being much more marked in strong sunshine than in dull cloudy weather. If the prevailing conditions persist during a maximum or minimum, the relative position of the curves remains unaltered; but if any change takes place with respect to clouds, the effect is at once noticeable. In the curves for June 9 (Plate VIII.), we have in the morning the various instruments reading very close together, the sky being covered with large quantities of cumulus cloud. After 11 hrs. we have a clear sky, and temperature rising steadily till noon, the gradual divergence of the curves being very well shown. Shortly after noon a maximum occurs—the sky remaining clear—and hence we find the positions of the curves, with respect to each other, unaltered. At 13 hrs. a minimum occurs, followed at 14 hrs. by another maximum; but in this case we have cumulus clouds passing overhead and checking the radiation of heat to the two Stevenson boxes. These boxes have now the effect of cooling the air circulating through them, and hence the curve for the fan apparatus crosses the others, and becomes the highest. The curves remain reversed till 16 hrs., when the sky was again clear, and then fall back to their original positions, the old form of Stevenson being the last to do so, as the double top keeps the improved form from being heated as easily as the other. At 17 hrs. the curves show a minimum point after a considerable fall of temperature. Although a small quantity of cloud was observed overhead at this hour, its effect is scarcely perceptible, as it was of a cirrus type, very high up. After 18 hrs. a steady fall of temperature sets in, continuing till 21 hrs., when observations were stopped. Whenever the radiation from the boxes may be considered to have fairly commenced, we find the curves for the old and improved Stevenson screens changing places, the former being now lower than the latter, as the double top and louvred bottom cause the improved form to lose heat less rapidly. Both, however, as the process of cooling goes on, gradually approach the curve for the standard apparatus. Throughout these observations the wind was north-westerly, varying in force from 0 to 2 (Beaufort Scale). The effect of varying wind force is only shown in the general form of the curves—their relative positions remaining almost unchanged. This shows that although in a dead calm the radiation effects are enormously increased, they still require to be taken into account in accurate measurements of temperature, even when the wind-force is considerable.

In the curves shown for 8th June one point is of especial interest, the same effect being produced as in one of the curves just discussed —but by almost opposite causes. In the forenoon the weather was dull and wet, the sky being overcast with a pallium of cumulus clouds. At 13 hrs. the clouds cleared away, the sun shining brightly. Observations were begun at 11 hrs., when the Stevenson screens read lower than the standard; the rain water drying off the louvre boards probably cooling them, and so reducing the temperature of the air passing over them. About 11·40 the curves cross and assume their usual positions. At 13 hrs. a maximum occurs, and the effect of the clear sky overhead and sunshine is at once seen by the standard crossing the others and giving the highest reading. At 14 hrs. we have the sky again overcast, and the lines rearrange themselves as before at a minimum point. At 15 hrs. another maximum comes in, the clouds breaking overhead and sun gleaming occasionally, and here again the standard rises—higher than the improved Stevenson, and coinciding with the old. After 18 hrs. the clouds cleared away almost entirely, but as the boxes had not been heated during the day to any considerable extent they give readings slightly lower than the standard, but gradually approach it as the temperature falls, and ultimately cross and take up their usual positions.

The readings of the thermometer with the silvered bulb are extremely good at first, the radiation effects being all reduced to a minimum; and the delicacy of the instrument remains almost unaffected. One great advantage of this instrument is that it can be much more carefully read than those in ordinary use, as the radiation from the body of the observer is almost without effect. But the silver becomes so much tarnished in less than a week as to be almost entirely ineffective, the readings being ultimately the highest throughout. Very great care is necessary in repolishing the thimbles, as they are liable to be scratched, which seriously impairs their reflective powers. It is intended to try experiments with nickel-plated thimbles, as it has been found that nickel stands exposure to the weather for a longer time without tarnishing.

The readings of the black bulb arrangement are on the whole very satisfactory. They are as a rule lower than those of the standard apparatus, sometimes so much so that one is led to suspect that the black bulb has too much of its surface covered. At other times curious points occur, which are not indicated by any of the other instruments, and of which the explanation is not obvious. As the readings are somewhat difficult to take accurately—the temperatures being liable to change before both thermometers can be read, and any error in the clean bulb is doubled by the process of reduction—these peculiarities probably arise from errors of observation, and it will be necessary to use the instruments for a considerable time before anything definite can be said. The chief objection to the instrument is that the black coating of the bulb is liable to be chipped; but as the adjustment of the amount of black surface does not appear to be very delicate, this will probably be easily got over.

The readings of wet and dry bulb hygrometers have been taken throughout in the fan apparatus and in the two Stevenson screens. The dew points, as calculated from these readings by means of Glaisher's Tables, present some interesting peculiarities—but as yet sufficient material has not been collected to enable any very definite conclusions to be drawn.

It was to be expected that the fan apparatus would give results more nearly approaching the truth than the others, as the operation of drawing the air through the wooden tube can scarcely affect the amount of moisture in that passing over the bulbs,—at least when the air is comparatively dry,—and the free circulation produced by the fan prevents the water evaporated from the wet bulb from remaining in its immediate vicinity, and so indicating a greater amount of moisture than is really present in the atmosphere. Again, the passage of a large quantity of air through the apparatus should enable us to get a better idea of the amount of moisture in the air around.

The dew points given by the fan apparatus are in all cases considerably below those given by the other instruments, being in one case more than 5° lower than the Stevenson. As a general rule, the curve of dew points for the improved Stevenson is the highest of the three, but it is in most cases an almost exact reproduction of that given by the fan apparatus. The curve for the ordinary Stevenson usually lies about midway between the two—on the whole nearer to the curve for the improved Stevenson than to that for the fan apparatus. On some days this curve resembles the others only in its general outline—the maxima and minima being greatly rounded off, and sometimes only hinted at. This effect is probably due to the thermometers being freely exposed underneath—evaporation and condensation of moisture from the grass neutralising the various changes.

It is intended to compare the dew points given by these screens during the hourly observations with those given by a direct hygrometer; the form to be used being that designed by Professor Chrystal. This consists of a copper box, nickel-plated, into which the bulb of a thermometer is inserted. By means of a double-tap arrangement communication can be kept up with two reservoirs, one of which is filled with warm water, and the other with water surrounded with ice or a mixture of snow and salt. The temperature of the water flowing through the box can thus be adjusted until a film of moisture has just begun to form on the plated surface, and the reading of the thermometer at once gives the dew point. With this instrument results differing from each other by not more than 0°·3 can easily be obtained.

A few experiments have been made with this instrument, but in circumstances under which the dew points given by the wet and dry bulb hygrometers approached each other more closely than usual, although still maintaining their usual order. The results are somewhat different from what was expected, but are perfectly consistent throughout. The direct hygrometer invariably gives the highest dew point, being always a little above the improved Stevenson. The mean of fifteen observations shows the dew points given by the improved Stevenson to be about 0°·7 lower than the direct hygrometer—those by the ordinary Stevenson about 1°—and those by the fan apparatus about 1°·5. These show a much closer agreement throughout than could have been expected; and the fact that the direct hygrometer is always highest tends to confirm the result arrived at by Mr Shaw of Cambridge, that the film of moisture begins to deposit on the silvered surface before the actual dew point has been reached.

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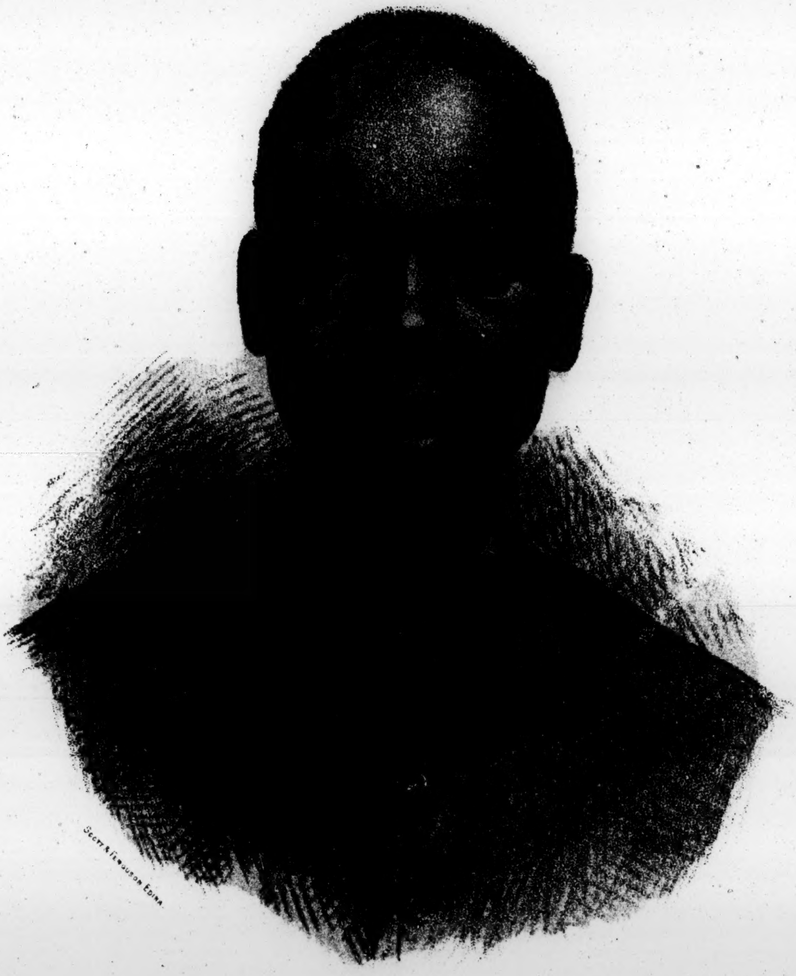
Proc. Roy. Soc. Edin. Vol. XIII. Plate IX.



Scott & Ferguson Edin^r.

A FOR BOY.

Monday, 6th July 1885.

Sheriff FORBES IRVINE, Vice-President,
in the Chair.

The following Communications were read:—

1. Notes on the For Tribe of Central Africa. By Dr Robert W. Felkin, F.R.S.E., F.R.G.S., Fellow of the Anthropological Societies of London and Berlin, &c. (Plate IX.)

It may be within the recollection of the Fellows of the Society, that in December 1883 I had the honour of reading, in this room, a paper on the Madi Tribe of Central Africa.

I have now to lay before you a similar paper on the For Tribe, which, as in the former case, I have written from notes of my own observations when in the country, and from information supplied to me by people of the tribe. I am able on this occasion to introduce to your notice a For boy, who has been with me since 1880, when I was in Darfur. The boy was rescued from slavery by General Gordon in 1878, and he entered my service at Dara in 1879. I hope it will add to any interest you may take in my remarks to see the only representative of his tribe, who, as far as I know, has reached Europe.

The country of Darfur is bounded on the south by 9° 30′ N. lat.; on the north by the 16th degree N. lat.; on the east by about the 22° 30′ E. long.; and on the west by the 28th degree E. long.

Darfur, or Darfor, means the land of the Fors, who were once the owners and sole inhabitants of the whole province. They have, however, been driven back into the western part of the country, the remainder of which is now inhabited by various invaders, namely, the Homr Arabs in the north, the Bertis Turkruri in the east, in the south-east the Rezigat, while in the south the Baggara and the Turkruri are mingled. There has been no intermarriage between the Fors and the strangers, and the regular features and lighter colour of the latter at once proclaim their Arab origin.

The whole population of Darfur may be roughly estimated at from 3 to 5 millions, about half that number being Fors; but it is impossible to obtain exact information on this point.

It is not my intention to give any account of the political history of the country, as that may be found in a learned paper by the late Dr G. Nachtigal, entitled "Darfor, die neue Ægyptische Province," *Petermann's Mittheilungen*, 1875, p. 281. Some further information may be obtained in Dr Perron's *Voyage au Darfour*, which is the translation of an Arabic work by Mahommed Ibn Umar or Mohammed el Tunsi. His notes on the manners and customs of the people are wonderfully correct as far as they go.

Darfur was taken by the Egyptians in 1874, after the battle of Menowatzhi, when Zebehr Pasha conquered and killed king Brahim, but the province was not really subjugated until after my visit there, for Haroun held out in the Marah mountains till 1881, when he was killed by the Egyptian troops under Slatin Bey.

The Fors are pure negroes, and are the most northerly tribe in the eastern part of Central Africa. They form one of the three great negro Mohammedan kingdoms, the other two being Wadai and Bornu.

I was unable to spare the time for making detailed measurements of the For people. The average height of twenty-five men was 173·0; of fifteen women, 168·7. Pulse, 72; respirations, 19. Temperature in the axilla, 97°·2 Fahr.

The following measurements of my boy's head are given as better than nothing. The numbers correspond to Virchow's table:—

1.	Height,	155·2
2.	Greatest breadth from glabella backwards,	20·0
3.	Greatest breadth above ears,	14·2
4.	Length of face from root of nose to lower border of chin,	12·1
5.	Breadth of face from one foremost edge of cheek bone to the other,	11·6
6.	Breadth of face from one angle of lower jaw to the other,	10·4
7.	Greatest breadth between zygomata,	13·0
8.	Length of nose from root to junction of nose and upper lip,	5·3
9.	Height of head from chin to vertex,	22·6
4.	Height of head from meatus auditorius to vertex,	13·0
15.	Distance between two ears at top of meatus auditorius,	12·4
16.	Upper breadth of nose from one canthus to the other,	3·4
17.	Lower breadth of nose on cheeks,	4·4
18.	Length of nose from root to tip,	4·6
19.	Breadth of mouth,	5·9
20.	Distance from meatus auditorius to junction of nose and lip, middle line,	11·8

21. Distance from meatus auditorius to root of nose, . . .	11·2
22. Distance from meatus auditorius to middle of upper lip, . .	13·7
23. Distance from meatus auditorius to chin, lower edge middle line,	13·0
24. Greatest circumference of head at glabella, ...	57·0
25. Arc from tragus to tragus over top of head, . . .	35·0
39. Arc from root of nose to inion, overhead, ...	39·0

TABLE OF PRINCIPAL INDICES.

Cephalic Index.

$$\text{Measure } \frac{\text{No. } 3 \times 100}{\text{No. } 2} = 71{\cdot}00$$

Nasal Index.

$$\text{Measure } \frac{\text{No. } 17 \times 100}{\text{No. } 8.} = 83{\cdot}01$$

Facial Index A.

$$\text{Measure } \frac{\text{No. } 4 \times 100}{\text{No. } 5.} = 104{\cdot}31$$

Facial Index B.

$$\text{Measure } \frac{\text{No. } 4 \times 100}{\text{No. } 6.} = 116{\cdot}34$$

Facial Index C.

$$\text{Measure } \frac{\text{No. } 4 \times 100}{\text{No. } 7.} = 93{\cdot}07$$

Colour of skin, Broca's Table No. 43–42.
Colour of eyes, Broca's Table No. 42 of the skin table, but darker.

Physical Powers.—I was not able to test the physical powers of the Fors, but both men and women are strong, and can march well. They carry loads from 70 to 80 lbs. weight with ease for fifteen miles a day, but they do not like the occupation, as oxen and asses are, as a rule, used as baggage animals.

Their sight, hearing, and smell are very good, but the sense of touch is not very acute, and their sensibility to pain is decidedly less than that of Europeans.

Reproduction.—Marriage takes place at about the age of 17. The women are prolific. I saw a good number of women with seven, eight, and nine children. Twins are common, and more especially welcome if females; a great feast is held after their birth, and the whole village rejoices. I never heard of a case of triplets.

Polygamy exists. Barrenness is common in the Gebel Marah district, where the men always make sure of a woman's fertility before marriage. In the other parts of the country it is not so common. Divorce does not take place in consequence of sterility. There are no restraints on population. Infanticide is unknown. If a girl should have a child before she is married, and its father will not marry her, he has to pay a fine of cows to the chief of the village. The child belongs to the mother's father, and when she subsequently marries it remains with him. If it should be a daughter, its grandfather is by no means displeased by the arrangement.

Hair.—The Fors have fairly good heads of hair, black in colour, and naturally frizzled in character. The men sometimes shave their heads, but will never plait their hair or otherwise ornament it. The women dress theirs with numerous small plaits, which are flatly pressed down on the top of the head, and then hang loosely as far as the shoulders. The hair is much greased with butter, scented by various substances. Some of the men have beards of which they are very proud; they do not shave them off, as they say it is wrong to make themselves look womanish. A man with a very long beard is very highly esteemed. The men shave the hair from the armpits, and from off the chest; the women pull out the hairs from under the arms by the roots. The hair on the pubes is not removed.

Colour.—The people are all very much of the same colour, No. 42 and 43 of Broca's table. They rub their bodies all over with butter or with castor oil. Small white patches, due to the absence of pigment, are occasionally met with, but are not nearly so common as in some other tribes; the natives attribute these patches to syphilis. One celebrated hunter was affected by this malady; it attacked the left part of his forehead, the bridge of his nose, and the upper part of his cheeks. It injured his power of smell, and he had in consequence to give up his place as chief hunter. The children are of a slightly lighter shade of colour.

Odour.—Their odour is rather offensive, although it is to a certain extent masked by castor oil, or by the various scents they use to perfume their bodies; still after a long march the smell from them is very noticeable.

Motions.—The Fors generally sleep upon the right side, with the right arm bent under the head as a pillow. When standing at ease, they balance themselves on one leg, leaning on a spear or staff, the other foot resting upon the knee. They are very good riders, and bestride their horses in the usual manner. They walk with a long, easy, swinging stride; the body is well balanced, the head slightly thrown back, and the arms are permitted to swing with easy grace. All their attitudes are unconstrained. They climb trees very well, swarming up them; no ropes or other aids are used in climbing. In moving heavy objects, such as the trunk of a tree, they make use of rollers and levers, and push, but rarely or never pull. They can move their scalps backwards and forwards. I never noticed them moving their ears, but found that they had great difficulty in opening one eye, the other being shut. They can extend each finger separately; they point at objects with one finger, often the middle one, but have no tricks of sleight of hand. Their joints are pliable, with the exception of their toes; in rope-making, however, they can grasp the strands with the great and second toes. They occupy the squatting position when following the calls of nature. The most common position for a woman to occupy in labour is that of standing, leaning against the hut wall. In isolated cases, a rope is suspended to the roof of the hut for the woman to support herself with (see *Labour*).

Clothing.—With the exception of a very few chiefs, who are rich and have come much in contact with the Arabs and adopted their costume, all the Fors are dressed alike. The men wear damoor cloth shirts, open at the neck, and extending to about the knee. They have large open sleeves, which they tuck up when at work. The women wear a loin cloth, and also a loose sheet, which is wrapped round the body and thrown over the shoulder, leaving the arms free. This is, however, dispensed with very frequently. Till puberty the boys and girls go naked, and then the girls wear a skirt only.

Tattooing.—The For men do not tattoo. A good number of women, however, make three vertical and two horizontal cuts on each cheek, which custom has evidently been introduced by the Arabs. In order to add to their beauty, the women also prick their lips with sharp-pointed thorns, and then rub in kohl to make them black. Kohl is also used round the eyes and on the eyebrows.

Personal Ornaments.—Some few ornaments have been introduced among the upper classes in Darfur from the Arabs. The men wear no bead ornaments, but a plain ear-ring is inserted into the top of each ear. They also wear rings, one of which is a wedding ring; unfortunately, I have forgotten upon which finger this is worn. The women wear a wooden stick about half an inch in length, or a small crystal through the left nostril. The septem of the nose and lips are never pierced, but ear-rings are almost universally worn. They also affect numberless necklaces and girdles made of various kinds of beads, and bracelets and anklets made of iron or brass, and more rarely still of silver. At festivals many of the women also wear tinkling bangles and small bells around their wrists, waists, and ankles, to please their lovers. Many women adorn their foreheads with three or four thin, round gold plates, having various patterns, and fastened to a band. Filigree ear-rings are also made of silver or gold, modelled after Arab patterns. Both men and women wear amulets and love tokens, which are suspended round the women's necks and fastened round the upper arm of the men. No ornaments are employed as badges of distinctive rank, nor have they tribal marks, save those worn in war (which see). The Fors never deform themselves, nor do they extract the incisor teeth, which is an almost universal custom among the tribes living farther south.

Customs.—The usual mode of salutation is by shaking of hands. To this is added kneeling on one knee, if the persons have not met for a long time. Women always kneel to men, and, rarely, a man kneels to a woman if she is a relation and they have not met for many weeks. Women always kneel to their husbands, except in private. Kissing is confined to mothers and their babies. When people pass one another in the streets they say "Kilonya." Members of a family meeting each other in the morning say "Konas kav kor," which is analogous to "I hope you have slept well." When friends or relations have been absent a long time, or been in any danger, and meet for the first time, they kneel down on both knees, put their arms round each other's shoulders, and then shake hands.

Rules of precedence in serving food are as follows:—Puggees, aged men, chiefs, younger men, youths.

Women are evidently considered inferior to men, whom they must respect and obey in all things. The aged women, however, as well as men, are treated with great respect and care; when beginning to bend with age they are not permitted to work in the fields any more, but are supported by their children.

The Fors are not particularly hospitable, and they are very suspicious of strangers. Should any appear in the village, they are closely questioned as to whence they come and what their business is; and if their answers are not satisfactory they are at once taken to the chief.

Both boys and girls are circumcised shortly before arriving at puberty. A feast is held on such occasions at which all the village takes part. If the children bear the operation bravely, they receive presents from their father.

The following is a rough description of the Fors' daily life:—They rise at dawn, and after washing, the man prays and then goes into the fields to work. The woman does household work and prepares the breakfast. When breakfast is over, the man returns to the fields, where he is soon followed by his wife, and they both work together till midday. Then the man rests while the woman prepares the dinner. After dinner, the man sits down and spins cotton, or makes mats or basketwork. When the woman has washed up, put the fire out, and fetched water, she joins her husband at his work, or else they severally go and join working groups, until the cool of the day, when they go again to their gardens and fields, and work until the sun has set. They never work in the huts, but in cool sheds provided for the purpose. No work takes place after supper, a few hours being then given to social intercourse, or occasionally to dancing. The very rich women and chiefs' wives spend most of the mornings in perfuming themselves, or bathing and dressing their hair. In the afternoons, they also spin and make light mats of grass, but all women, to whatever class they may belong, always do the cooking.

Huts.—Some of the huts in Darfur are the ordinary beehive grass huts, but by far the greater number are made with stone and mud walls; they are circular, and very large. The people build about two feet each day, and then leave the work to dry till the next day; they never build higher than they can reach, and no scaffolding is used. The roof is supported by five poles, one of them being in the centre, with cross bars placed on the top to which circular bundles of supple sticks have been fastened. The roofs are conical, and overhang the walls about three feet; the thatching is very neatly done. The entrance is small, and is made still smaller by a stone which is placed in it on the ground. The door is of wicker-work, made to slide backwards and forwards, and fastened behind by a bar and pins; a handle is placed in the middle of it, both inside and out, to move it with. There are two fireplaces—one chiefly for cooking, made with three stones; the other for the people to sit round, especially in the cold season, as the mornings are very chilly. There are no chimneys or windows. The young men in the village have one hut in common for sleeping, into which they are banished at puberty. Outside the hut are cooking places, store-houses, and cow seribas, all of which are enclosed by a fence, and beyond it extend the gardens.

Food.—Although the staple food of the Fors is dhurra, it must not be supposed that this is the only item in their bill of fare, for their larder is well stocked with fish, flesh, fowl, insects, vegetables, and fruit. Fish is very abundant in the lakes and the rivers of western Darfur. There are many different kinds, all of which are freely eaten by the natives with the exception of the eels, which it appears are only consumed by the blacksmiths (see below). Cows, sheep, goats, gazelles, hares (rare), rabbits, wild dogs (eaten by wandering beggars), buffaloes, various antelopes, elephants, rhinoceros, rats, and wild boars, form a plentiful and varied supply of animal food.

Fowls are reared in large numbers, and pigeons, guinea-fowl, parrots, storks, wild ducks, owls (eaten only by beggars in great want), and various small birds, are found in abundance. Ostriches are eaten sometimes, but only when other food is very scarce, as their flesh is supposed to induce a disease, the principal symptom of which is a very red and repulsive face. Locusts, water beetles, and grubs from trees, are considered luxuries, and form favourite entrées. The vegetables are tomatoes, bananas, cucumbers, water melons (used also for washing and drinking purposes when water is scarce), various marrows, and onions. The fruits are not very varied; dates, bananas, lemons, and a kind of cherry from which wine is made, are cultivated; and sugar-cane grows in great abundance in the west. Wheat is grown to a limited extent in the Gebel

Marah district, but, curiously enough, it is never eaten, but exported as an article of barter. Rice is also sparely grown in some parts of the country.

Dhurra and rice are ground, and then made into bread, as also a root which is considered poisonous until well boiled. In order to keep the bread, which is in the form of pancakes, it is broken up into small pieces, dried for a day or two in the sun, and then preserved in leathern sacks. Milk is much used as an article of diet; it is obtained from cows, sheep, goats, and camels. Very good butter, cheese, and curds are made. The butter is chiefly used for anointing the body and as pomade; for this purpose it is mixed with dried odoriferous plants. The flesh of goats and sheep is considered to be the best meat, and that of young kids the most strengthening. As a great luxury, a fat she-camel is sometimes killed; this, however, can only be indulged in by rich chiefs. Meat is not much used in hot weather, fowls being preferred then, and they are also considered the best food for invalids. Rice boiled for a long time in new cow's milk is one of the best and most expensive dishes. Cow's liver, raw, with Cayenne pepper, is eaten by rich people and by invalids. The brains of all animals are thought a great delicacy; marrow is also a tit-bit; the bones are cracked, and it is taken out with a chop-stick or knife. The blood of bullocks and of fatted he-goats is eaten after being well boiled, strongly flavoured with Cayenne pepper.

The poor buy meat at open-air sales; the rich kill their own cattle, and after drying the meat in the sun, store it away in huts. These are built like the dwelling huts, and are surrounded by thorn hedges; there are separate store-houses for meat and corn. The granaries are constructed as follows:—A circular framework is made of poles, and this is filled up by bundles of dried grass, bound securely to it by rope made of fibre. The roof is formed of thatch, shaped at the top like a pinnacle. A deep hole is dug inside the hut, and it is lined with mats or hides, and then filled with grain. The meat store-houses are narrower, higher, and stronger; the door is made of very strong wickerwork, and halfway down the roof a wicker-lattice provides for ventilation. Inside the hut are shelves made of sticks on which to support the small pieces of meat; the larger pieces are suspended from poles fixed in the roof.

People of small means, who have less corn to stow away, build miniature granaries within their dwelling huts; they are supported by stones, and the top is movable.

In times of scarcity the people resort to wild fruits, roots, and leaves; at all times the poor live chiefly on dhurra and wild fruits. When hard work has to be undertaken, mutton, dhurra, porridge and milk are preferred, as they are considered to form the most strengthening diet. Oil is only used for frying purposes. The chief spice is Cayenne pepper; it is taken with almost everything, and even the poorest person contrives to cultivate the plant. Various other spices have been introduced into the country by Arabs. Onions are much relished, and largely cultivated. The best salt is obtained from a salt lake near Gebel Marah; it is exceedingly expensive, and is used as money. The salt eaten by the poor is procured either from burnt grass or from salt beds. No sugar is used, but sugar-cane is largely chewed, and the people are very fond of it. Honey too, of which a large quantity is obtainable, is much relished. Earth is never eaten.

Fire.—Fire is obtained whenever it is required by friction, a round, soft, pencil-shaped piece of wood being rotated by the hands in a small hole cut in a flat piece of hard wood. I am not aware of any superstitions connected with the kindling of fire.

Cooking.—Cooking is performed as a rule by the women; even the richest women prepare their husband's food. The food for both men and women is cooked together; there are no professional cooks. Culinary operations are carried on either in the dwelling hut or in small huts erected for the purpose by the wealthy. Meat is preferred well cooked; it is roasted, boiled, stewed, and fried. It is preserved by drying in the sun or cured by smoke. This preserved meat is either eaten as it is or soaked before cooking. Meat is never salted. Roasting is managed as follows:—Two forked sticks are placed on either side of a bright fire; another is laid across them, from which the meat is suspended. In order to stew or boil the meat, flat stones are placed round the fire in groups of three, upon which large earthen jars are placed; for frying, shallow round pans are used. No pots are hung over the fire. Sometimes a whole or half a sheep is roasted at a time; a spit is put through it, and it is turned occasionally. Meat and bread are never baked in the ground, but vegetables are prepared for use as follows:—A hole is dug in the ground, and sometimes lined with flat stones; in this a fire is lit, and is subsequently removed to be replaced by the vegetables, which are wrapt in large leaves (Dameregy); they are then covered with earth and remain until cooked. These ovens are not permanent structures, but after being used they are filled up, new ones being constructed as occasion requires. Hot stones are not used in boiling. Bread is baked on large flat stones, supported over the fire. Vegetables are generally boiled in the same pot with the meat. Butter is used for frying. Dripping is collected, and after being scented with various herbs is used as pomade and for anointing the body. In the huts there is sometimes a permanent fireplace, enclosed on three sides by large flat stones and on the fourth by a lower one.

Cooking vessels are made of earthenware, the only exception being the iron pots which are used when travelling. Most of the vessels are round with flat bottoms, and without necks; they are always well washed after use and scrubbed with sand. Knives, and sticks bent at one end, are the only cooking utensils employed.

Corn is ground between two stones, mixed with water and baked in thin cakes, but the more usual plan of preparing it is to boil it into a thick porridge; it is served in a large pot, with meat and gravy round it. No yeast is employed.

If animals have been shot by a poisoned arrow, the flesh around the wound is cut out as soon as possible, and the entrails of such animals are thrown away. No pickles are made, and the only fruits preserved are the *kuma* and *cogna*, small fruits about the size of grapes; they are simply dried in the sun. They are either eaten in this condition, or soaked in water and softened, the water being also drunk.

Outside each village there is a public yard, in which all rubbish is deposited; it is subsequently used as manure.

Drinks.—No spirits are manufactured. Water and milk are used freely. Beer is made from dhurra, and wine from *kuma*. The beer is brewed as follows:—The dhurra is placed in a hole in the ground until it begins to sprout; it is then spread out in the sun to dry. then cleared of earth by shaking in a round sieve made of plaited grass, and afterwards ground between two stones, mixed with ordinary flour, and put into large jars, which are then filled up with water. After being well stirred, dry flour is scattered upon the top of the water, and the pots are covered with a lid made of basket-work. In a few days it begins to ferment; more water is then added, and it is well stirred and again left for several days. A little more water is then poured on it, and it is strained through a sieve made of damoor cloth. It is ready for use the next day, and will keep for a week; the longer it is kept the more intoxicating it is, and after a week it becomes sour and unfit for use; it is kept in jars in the huts. Each family brews for itself, but widows sometimes make it in large quantities and retail it. The utensils employed in the manufacture of beer are earthenware pots of various sizes, sieves made of plaited grass and others of damoor cloth, and sticks bent at one end, which are employed for stirring.

The wine is made as follows:—The fruit is either dried first for the best wine, which is intended to keep a long time, or it is used quite fresh. It is then well boiled, strained through damoor sieves, placed in small jars with tight-fitting lids, and put in a dark cool hut. It is ready for use after a few days, and is very intoxicating. Kogna fruit is sometimes soaked in water for a day or two, after which the water is drunk.

Meals.—As a general rule, three meals are partaken of in the day—breakfast, two hours after sunrise; dinner, an hour or so after the sun has reached its zenith; and supper, two hours after sunset. Breakfast and dinner are partaken of separately at home, but supper is eaten in a public yard, where the men and boys over 14 meet together for the purpose. A large fire is made in the yard soon after sunset, and social intercourse is enjoyed by its light until the supper is brought by the women. The latter and the children eat at home, often outside their huts together with their neighbours. Each person provides his own food for the public supper, and those who are not possessed of means for the provision of a good one must eat at home.

Breakfast consists of stiff porridge with milk, a little salt being sprinkled over it. All help themselves with their fingers out of the same dish.

For dinner they take either porridge or bread cakes broken up into small pieces, with chopped or minced meat and gravy round it.

Water is drunk at dinner out of a gourd, all drinking out of the same, and holding it between their wrists or between the left hand and the right wrist. It is a very general custom for the right hand alone to be used in eating; this practice was introduced by Arab fakirs hundreds of years ago.

Supper, like breakfast, consists of porridge and milk; roasted meat, stews, and vegetables are added to create variety. Water is almost invariably drunk with food; beer and wine are drunk between meals, the only exception being at great feasts, when they are immoderately consumed.

Feasts take place at births, weddings, and at the great yearly religious festival. At funerals there is a solemn meal, when laughter and jokes are unheard. A description of these will be given later on.

On occasions of rejoicing a man will call his friends together to drink with him. Friends are well looked after at meals, tit-bits often being presented to them. Meat is sometimes ready cut into small pieces before being placed on the dish; sometimes, however, it is served in joints; occasionally also a sheep is served entire. In this case one of the party, generally a young man, carves for everybody; otherwise each person helps himself. The older people always take food out of the dish first, for though visitors are requested to begin, they would be considered very rude if they did so before older persons than themselves; the same custom applies to drinking. Food is always taken with the fingers, and it is considered very unbecoming for all the fingers to be put into the mouth; the first and second and thumb are used. Young people are not supposed to talk before their elders unless they are spoken to; and if anything is needed at a repast, they are expected to make themselves generally useful. When no youths are present, the women are called to fetch or take anything away, but they are required to crawl on their knees when the men are engaged in eating. It is thought the height of impropriety for a woman to convey anything to her mouth when in the presence of her husband or of any grown-up man.

The Fors are considered by surrounding tribes to be very objectionable in their eating, as they like their food so "high." There are no traditions that cannibalism has ever prevailed in this country, and the Fors speak with the greatest contempt of the Niams-Niams on account of their cannibal propensities.

Tobacco is not smoked, but chewed and snuffed, and no other narcotics are used. The tobacco is indigenous, and very strong. It is carried about in small bundles, the leaves having been first dried and broken up small and mixed with fine wood-ashes, and it is rolled up in palm leaves. After a plug has been chewed it is stuck behind the ear till next wanted. Various roots and barks are chewed for medicinal purposes. Some of the Fors who have come into intimate connection with the Arabs have learnt to smoke, but they are looked down upon by their compatriots.

Religion, Fetishes, &c.—It is a very difficult matter, if not impossible, to give any account of the original religion of the Fors. Mohammedanism has been professed by them for hundreds of years; at the same time it is tempered by their original beliefs, and a great many of its tenets are totally ignored. For instance, they are so much addicted to drink that the decrees of Islam on this point remain altogether unregarded, although several of their kings have made great efforts to put down this vice.

In the following remarks about their religious beliefs it will be perfectly possible for the intelligent reader to recognise which of them have been assimilated from the teachings of Mohammedan fakirs.

"Kilma" is what seems to correspond to our idea of "soul." It is called "the power of the liver," for, believing that the liver is the seat of the soul, it is considered that an increase of a man's own soul may be obtained by partaking of an animal's liver. Whenever an animal is killed its liver is taken out and eaten, but the people are most careful not to touch it with their hands, as it is considered sacred; it is cut up in small pieces and eaten raw, the bits being conveyed to the mouth on the point of a knife or the sharp point of a stick. Any one who may accidentally touch the liver is strictly forbidden to partake of it, which prohibition is regarded as a great misfortune to him. Women are not allowed to eat liver, and are believed not to possess a "kilma."

When a man dies his kilma is supposed to go to Accra, and there he is told whether he has been good enough to go to Molu. Molu is the ancient native name for God. The name of Allah is used now by many of the people for God, but they have a very confused idea as to the difference between God (Allah) and the Shereef at Mecca. Some few of them go on pilgrimages to Mecca, and they say that this Allah is a very fat man, who lies on a white mat and never does anything, but receives those who come to him, and lets them kiss his hand. When a man starts on this pilgrimage he takes with him a small drum called Beedi, which he beats in all the villages he passes through. It has a very low, solemn sound, and is a signal to the villagers that he is going to see Allah, and that they may join him if they like. Perhaps a party of five or six is made up altogether, and the rest of the people are satisfied with crying out, "Aga be nasaba bani, zidzi domabani ye ka duo deba, dinzidisi dongab ani dinesidingtong suma karaky," the meaning of which is somewhat as follows :—"You are going to our master's house, give him my hand, and tell him that I am so weak and that his house is so far that I cannot go." The district of Khartoum, through which they must pass to get to Arabia, is called Urebiah, and Arabia itself Baribaru, or "the country beyond the water." When the pilgrims come back they are called Arch-barr, and are considered very holy; they never have their heads shaved, and are supposed never to do wrong. Their title must not be confused with Arch-barch, a term of honour sometimes bestowed on people in acknowledgment of bravery.

The dead are supposed only to stay in Accra about a day, when, if they have been good, they go to Molu, who lives in Jouel, "the sky," and are very happy there. If they have been wicked, they go to Uddu, the place of punishment, where they meet with all sorts of disagreeable things, and are finally burnt up. The people are very fond of singing a song which speaks of the fire in Uddu, rejoicing greatly because it has plenty of work to do in burning up wicked people. The oldest tradition, and one which is still firmly believed in the extreme west of Darfur, is that after death a man remains in the grave for two or three days; he then passes in a mysterious manner to a new country, where he becomes young again and marries. Women, however, are supposed to have no life beyond this one.

The ghosts of departed spirits are called "Malal"; they are said to appear to their friends most frequently during the first few nights after their decease, and to be clad from head to foot in white damoor cloth (this material forms their shroud), and they appear much taller than when in life. They are supposed to visit houses during the night, and to alter the position of different articles of furniture. Should any one be unable to find some article in the morning, they commonly say, "So and So's spirit paid us a visit last night," and thus account for its temporary disappearance. The ghosts are thought to hide, but not to steal things.

Great fear is felt of going into or near burial-places on dark nights, as the apparition of ghosts is dreaded. They think that if the grave has not been firmly built, and any air finds its way in, there will also be room for the spirit to find its way out. This spirit, however, is not the "kilma" which has gone to Accra, and which possesses no power of return.

The Fors have priests or fakirs, who go by the name of puggees. They are in no sense hereditary, and there is no ceremonial induction into their office. Any one may become a puggee if he chooses, but he must first be educated by a priest, in reading and writing, in the Koran, and in the For law; for the Fors have a written law, which differs considerably from that found in the Koran. The date at which it was reduced to writing I was unable to ascertain, but it is certainly more than 300 years old. Some parents set apart their sons to be priests, and send them to be educated while still very young. The puggees are the teachers of all who wish to learn, but the instruction they give is very meagre; only a little reading and writing are taught, and a few prayers from the Koran. The schools are held in the evening after the work of the day is over, and are conducted by firelight. The puggees have a great deal of influence over the sultan and chiefs, who consult them much, and generally follow their advice. They take precedence over the chiefs, and nobody is allowed to eat with the sultan but the priests. Chiefs are sometimes priests too. There are three ranks of priests; they wear little white caps, the embroidery of which tells their status. Although each puggee is under no practical obligation to obey those of higher rank, still they do defer to their opinions, and are ready and willing to receive instruction from them. The difference in rank is caused by age and experience; those men too who have been a pilgrimage to Mecca are naturally more respected, and hold a higher rank than their fellows. The puggees appear to be sincere in their beliefs; they do not practise austerities or live secluded lives. They may marry, and have as many wives as they please. They do not as a rule do manual work themselves, their time being chiefly occupied in teaching, writing amulettes or charms, in attending the councils of the chiefs, and officiating at the various religious ceremonies. They do not pray so continuously as their Arab compeers, nor do they spend so much time in telling their beads. They advise the chiefs in points of law, and act themselves as judges, most matters being submitted to them for decision, but in cases where the penalty of death or mutilation is passed, the chief's consent is necessary before the sentence can be carried out. The puggee's wives and daughters are the only women who are taught a smattering of reading; even these women do not pray, but it is said that they will go to Jouel if they lead exemplary lives.

There appears to be no idolatry in Darfur, and the various powers of nature are not associated in any manner with various gods. The Fors used to believe that they alone worshipped a God at all, and this idea still lingers, especially in the west and among the very ignorant. The one God Molu, who lives in the sky, is believed in and worshipped. He is regarded as the Creator of men, and as Supreme Ruler of the world. Prosperity and adversity alike are believed to be the result of his ordaining; and when evil happens or death occurs the people console themselves and each other by saying that they could not help it, and that Molu willed it. The wind is thought to be Molu's breath, and it is considered very wrong to swear at it, even though it should unroof their huts or damage their corn fields. The thunder is supposed to be Molu speaking to some one, and is feared in consequence. They attach considerable importance to the rainbow, believing that Molu causes it to ascend from the water to the sky in order to prevent men thinking that there is no God, and to warn them that if they do not behave themselves they will be burnt up in Uddu with fire like the red of the rainbow. It seems to be rather a difficult thing to get to Jouel, otherwise heaven; most of the people seem rather to expect to go to the other place, and if they do so they will never leave it until the fire ends their existence; the length of time that this occupies depends upon the life they have led on earth. They believe that the puggees and their sons will certainly go to Jouel, and their wives and daughters also appear to have a pretty good chance, as also the Medchera, who are the puggees' pupils. In fact, all learned men are considered more likely to be rewarded in the next world than the ignorant. If a man has accidentally killed a puggee, he is supposed to inherit the priest's spirit, and will therefore go to Jouel. If a man is killed in battle, or if killed or murdered by a For, he will go to Jouel, and be provided with a white horse. If any one murders a man, the murderer inherits his spirit, and has to bear the consequences of the murdered man's actions in the next world. This is, however, not the case if one man kills another accidentally. The priests and those who have been taught by them are influenced by a strong desire to be received by Molu when they die, and are greatly afraid of the punishments meted out in Uddu. The unlearned people do not think much about an after life, and are far more influenced by the fear of having their hands cut off if they steal, or their lips if they are guilty of falsehood. There are still a few stone huts in existence, which were devoted to the worship of Molu before Mohammedanism was introduced, and the people still reverence them. Drunkenness is not considered to be a sin, nor is want of hospitality to strangers or unkindness to human beings thought a mortal sin, if I may use the expression; but ill-treatment of tame animals is said to be very wicked, as they have to suffer without being able to defend themselves or to retaliate. Animals, however, are not believed to have souls; when they die there is an end of them.

Animals are not held sacred, but there is one sacred bird; this bird is often seen sitting on the trees near water. When a puggee notices one of them in this position, he calls out to it "Te bate salewate" (?), at which the bird dives into the water, returns to its perch, and shakes the water from its wings. The priest runs underneath, in the hope of this water dropping upon him, as it is supposed to contain the spirit of Molu.

The Fors have another very strong belief, which has been unaffected by the Mohammedan religion, that a great spirit lives on the summit of Gebel Marah. They do not worship him, but they believe he has an innumerable army of spirit servants, zittan, who possess extraordinary powers. A limited number of magicians are supposed to stand in intimate relation to this great mountain spirit, and requests made to them are conveyed to him, and granted, if they be accompanied by a sufficiently large present to the magician. The spirits are supposed to reside in large trees; they protect cattle from robbers; and it is a curious fact that, with an exception mentioned later on, no For would dream of stealing another man's cattle, as he thinks he would be at once seized upon by the zittan, become insensible, and so remain until the owner of the cattle arrived on the scene. Any one can enlist the services of a zittan to protect his house, and more especially his milk-pots, and epilepsy in girls is said to be caused by them. The girls are supposed to have interfered with the milk-pots, or stolen the milk, in the absence of their mother. The same disease is believed to attack them as a result of misconduct under a tree inhabited by a zittan (see *Epilepsy*). The brides also have a wholesome dread of these trees, for if they pass under them without wearing an amulet they will be sterile.

The old custom of praying to Molu has become almost obsolete, and has been replaced to some extent by a few prayers from the Koran learnt from the puggees. The practice of regular prayer, however, is now limited to the educated classes, and the poor people do not pray at all. In the enclosures of the rich there is a small place surrounded by stones, and carpeted with sand, set apart for prayer. The father prays at one time, the sons at another. The regular prayer hours of Islam are unobserved, and bead-telling is only in vogue among the puggees, the chiefs, and a few of the rich people.

Warriors returning from war are not allowed to enter their village until they have seen a puggee, and he has offered a prayer.

No idea appears to prevail of the existence of an evil spirit tempting people to do wrong.

There is a very ancient belief prevalent that some men are possessed of the power of transforming themselves into wild beasts, *e.g.*, lions, jackals, hyenas, and that when in this condition they are able to traverse immense distances in a remarkably short time. They have also the power of divination, can restore lost cattle, tell fortunes, and perform various other miraculous feats. They are well versed in the medicinal properties of various roots, and the knowledge of these is committed to writing. One or two of these manuscripts which I saw were very old, but I was unable even to procure a copy of any one of them. All these powers are believed to be bestowed by the great mountain spirit, and they are not hereditary.

On the death of one of these men there is always a very lively competition for his manuscripts, the proceeds of which are handed over to his youngest son. These men are not bound together by any common interest, but are all deadly rivals, and use every means in their power to damage the repute of their opponents.

Social Relations, including Education of Children, &c.—Children are brought up very strictly. Disobedience is not permitted, and is very rarely seen. They are punished either by whipping or by being tied up without food or water for a given time. They are compelled to be very polite; they may not sit in the presence of their parents, nor may they speak when their elders are conversing, nor play about the hut. If they wish to amuse themselves, they must go to the village yard. They are just as respectful and well-behaved to women as to men, also to strangers.

As soon as they are old enough they are taught to make themselves useful—first, they must help their mother about the house and garden, and fetch water. They are then taught to spin, to dance, and to fight. A little later they are employed in tending the cattle and in helping their parents in the fields. There does not seem to be much systematic instruction given them in any of these things, but they are obliged nevertheless to perform their duties in a satisfactory manner.

With the exception of the schools for boys who are set apart for a higher education, the children do not receive much schooling. The puggees hold classes for an hour or two after supper, by the light of large fires, and in these the boys are taught a smattering of writing and reading, and to repeat various portions of the Koran. Those who are going to be educated for priests live in a puggee's village, where only puggees and their pupils reside. There are sometimes 200 or 300 of the latter, and no females are permitted there.

Treatment of Women.—Notwithstanding that the women associate with the men constantly in all their daily pursuits, they are by no means considered their equals, and are obliged to pay very great respect and absolute obedience to their husbands. They are not supposed to possess souls, and do not receive any education. Great consideration is shown towards women when they are old, as well as towards aged men. Widows have a large amount of sympathy shown them, their female friends going daily to lament with them after the death of their husbands. If good-looking, however, they usually marry again in a month or two's time. When women die they are buried without prayers. On the whole, the women make fairly good mothers, but indifferent wives; one cannot, however, say that the men make much better husbands.

Festivals.—The oldest festival which the Fors possess appears to be that of "sowing the seed." In the days when the sultan of Darfur lived in great pomp, it was carried out on a very large scale, and even now it still obtains and is observed by the chiefs of all the For districts. It is a kind of consecration ceremony, and is performed now in the following manner:—As soon as the ground is ready to receive the seed, a day is set apart for the ceremony, and messages are sent by the chiefs to all the surrounding villages, inviting the presence of the people to take part in it. They all assemble by midday, when beer is partaken of under the shade of trees. A small company of virgins, the most beautiful that can be found, are each provided with an ornamental wickerwork basket containing seed; these baskets are covered with fresh green leaves, and sometimes decorated with flowers. A procession is then formed; the virgins, carrying the baskets on their heads, lead the way; next come the musicians, and after them a group of unmarried young men and women dancing; then the chief, decked out in his best, generally riding on a horse, and accompanied by a few puggees (this only in recent times) and magicians. He is followed by the heads of the villages, and afterwards by the villagers themselves, and the rear of the cavalcade is formed by the women, carrying on their heads large pots of beer and all manner of provisions. They proceed some distance, and halt in a forest glade, in which a small piece of ground has been cleared and prepared for sowing. Here halt is made, a prayer is offered to Molu asking him to take care of the seed, and to supply them with plenty of rain, in order that they may have an abundant harvest. Each of the virgins then makes a hole in the ground and plants one seed. Then the chief plants a seed, after which all the people follow suit in order of their respective ranks, the virgins having first handed round their baskets, from which each person takes a seed. As soon as this ceremony is over the whole company separates into two parties, the men on the one side, the women on the other, of the glade. The people belonging to different villages group themselves together, the food is set out, and the midday meal takes place. The afternoon is spent in singing and dancing, and at sunset they return to the chief's village, where large fires are lit, and a convivial evening closes the day.

The next in importance of the For festivals is the great Mohammedan feast of Bairam, which lasts for eight or ten days. A large level piece of ground is enclosed by stones and strewed with sand. Within this enclosure the male portion of the population meet after breakfast, prayers are said for an hour or an hour and a half, and sometimes a short exhortation is delivered by one of the elder puggees. The rest of the day is spent in feasting, singing, and dancing, in which latter of course the men are joined by the women. During the days of this festival an entire holiday is taken by all the people, work in the fields ceases, and their time is wholly given up to prayer and feasting.

I have now to describe the proceedings which follow the birth of a child. A few hours after the child is born messages are sent round by the happy father to all his friends and relations living in the neighbourhood, inviting them to assemble in the village yard. A puggee is also invited to attend, and for this duty he receives a present. It is true that he generally makes a show of declining the gift, saying that it is his duty to come, but it would be considered bad form on the part of the father were he not to insist on its acceptance. Prayers of thanksgiving for the birth of the child are first said by the puggee and the grown-up men; these prayers last about half an hour. Afterwards the boys join the men, and a feast takes place; the father provides the guests with food, but it is considered a friendly and complimentary thing for each to bring a little offering of food. When the meal is over the old men are invited by the father to accompany him to his house to drink, while the younger men and boys, being joined by the fair sex, spend the night in dancing. Seven days after the child's birth the people assemble again outside the father's hut. The father and mother, who holds the child, stand in the doorway, and their nearest relations are grouped on either side of them. The puggee then arrives, and asks the father what the child's name is to be. He then reads a prayer, and afterwards calls out the name, and the ceremony is closed by another prayer. For the performance of this duty the puggee is not allowed to receive payment, and it can only be performed by the highest class of priests. The name given to the child on this occasion may never afterwards be altered. The rest of the day is spent in singing, telling tales, and then in dancing, the child being exhibited with much pride, and if it happens to be a daughter the father receives very hearty congratulations, the wish being always expressed that she may grow up to be very beautiful, and to be as supple as a bending branch, in order that his riches may be increased by an extraordinary large dowry.

Marriage Customs.—I have referred in another place to courtship and elopement; I will here describe the nuptial ceremonies.

Large stores of food and immense quantities of beer and wine are prepared for the marriage feast, and if a very poor man is about to be married he is allowed to select a cow and a few sheep from his richer friends' flocks, provided that he kills them where they are feeding, and subsequently explains why he does so. If the bride and bridegroom live in different villages, the wedding takes place in the bridegroom's village. The marriage ceremony is observed in the evening in the village yard. The fathers, brothers, and invited friends assemble together, but, strange to relate, the bride and bridegroom themselves are not present. Prayers are said, and then the priest, standing in the midst of the group, announces that the bride and bridegroom, giving their names, are hereby married, and calls upon the assembled company to bear witness to the fact. As soon as this is over, the man in the company who has the loudest voice calls out with all his might "Ku-ru-ru," in order that the bride and bridegroom, who are in adjacent but separate huts, may hear that their marriage is accomplished. Then food is served, the most of it being provided by the bridegroom's father; the bride's father, however, provides a small share. The boys are allowed to join in this feast, and when it is over the younger portion of the company dance all night long, the older people retiring to the house of the bridegroom's father to drink. More or less dancing takes place for several days, lasting, however, only two or three hours in the evenings. The drinking goes on until the beer and wine are finished, the visitors going away at night, if they live in the village, and returning early next morning. If they are from a distance, house-room is provided for them. Among the higher classes, singing and dancing women, of whom there is a small class in Darfur, are engaged to add to the enjoyment of the evening. Music is always provided.

During the following week the bride and bridegroom do not see one another; the bride is engaged in perfuming herself, dressing her hair, and in other mysteries into which I have not been initiated. The bridegroom is occupied in counting over and over the dowry which he will have to pay for his wife, and in receiving the visits of his young male friends, who help to wile away the weary time of waiting by songs and stories, expatiating on the charms and duties of wedded life, and expressing, in terms of rapturous eulogy, the captivating graces of his dusky bride.

On the sixth day after the wedding the bridegroom sends the dowry to his father-in-law, and if it be correct he receives a message to say that he may arrive to claim his bride next day. In the morning the bridegroom's unmarried friends take presents from him to the bride, such as one or two cows, a few loads of grain, ornaments, &c. In the afternoon the bridegroom is conducted to the bride's hut; she meets him at the door, and he presents her with the marriage ring, she making him in return a present of a love token and a ring. He then enters her hut with some of their chosen companions, and another feast is held outside provided by the bride's father. After this is over the father of the bride retires, and the bridegroom, leaving the bride, joins the company. Soon after, the bride is taken round the village, preceded by music and lighted by torch-bearers, and after having received the congratulations of everyone she retires to her hut with some dozen of her female friends. A few hours later the bridegroom is conducted thither by an equal number of his friends, who remain outside the hut, he alone entering. These young men then ask if they too may enter, and having gained permission they arrange for three or four engaged couples to keep watch over the bride and bridegroom for the night. This watching is kept up for several nights, and three or more may pass before the bride and bridegroom lose their patience and send their friends away. Then at last the marriage is consummated amidst the "Ku-ru-rus" of the assembled friends. The next morning the wife leads her husband and presents him to her parents; he looks them in the face and speaks to them for the first time since his engagement; he salutes them, and presents them, as also his wife's unmarried brothers and sisters, with a ring. He lives with his wife at his father-in-law's until his first child is born, when he is permitted to take his wife away and set up housekeeping on his own account. During the whole of this time the father-in-law has to pay all housekeeping expenses for the young couple, and the husband is entitled to three meals during each night. Amongst the poorer classes the whole of these festivities, which usually occupy twelve or fourteen days, are compressed into seven days, the bridegroom being led to the bride's hut on the evening of the marriage day.

Burial Customs.—Funerals take place within a few hours of death. The corpse is wrapped in a winding shroud of damoor cloth, and carried to the grave on a rude bier hastily constructed of wooden poles lashed together with rope. It is not used a second time, but is burnt. Graves are dug 6 or 8 feet deep and covered with stones, but the Arab method of burial is being rapidly introduced into the country. The graveyards are situated at some considerable distance from the villages.

When a woman dies her body is buried without much ceremony, but her friends accompany it to the grave uttering mournful cries. When a man dies, however, a priest is sent for, and his friends and relations collected. The priest recites some prayers, and the body is then conveyed to the grave, accompanied by the friends and by women wailing for the dead. The usual Moslem rites are performed, and the company then disperses, to meet again a little later in the outside village yard, where an hour is devoted to prayer, and where they then hold a solemn funeral feast. The food for this occasion is provided by the deceased's nearest kin, but contributions are also brought by friends, and if they should arrive too late the animals they give are reserved until two months later, for it is the custom to kill a cow or a goat every two months for two years after the death of a father. On such occasions the meat must not be taken into the hut where the man died, but eaten outside, and the whole of it consumed before nightfall. Any passers by are at liberty to partake of this meat. This custom is by no means universally carried out, for one reason, on account of the expense, but a man who thus honours his father is much respected. If it should be done by a husband in memory of his wife, it is considered to be a mark of extreme affection for her, and men will often do it for the sake of what people will say. No animals are offered as a sacrifice at funerals.

Superstitions.—The Fors are not particularly remarkable for their superstitious beliefs; other tribes I have visited are far more credulous. Some strange ideas, however, must be noticed.

The cry of the owl is believed to foretell a death. It is supposed to say:—"To-morrow a grave will open for some one." A gazelle crossing one's path is taken as a good omen. To knock one's left big toe against anything on going out in the morning is supposed to bring bad luck. It is also very unlucky to forget anything and to return for it, especially when going out hunting. It is a very lucky thing for any food to fall to the ground when eating. It must be picked up and swallowed with any earth that may adhere to it, for in the next world, should a man be accused of having starved his body, the earth will bear witness that he has fed it. There is a great objection to cutting anyone else's nails, for should the part cut off be lost and not given into its owner's hands, it will have to be made up to him somehow or other after death. If a person cuts his own nails he bears the consequences of his own acts. The nail parings are buried in the ground. If the sound of a drum is heard proceeding from Gebel Marah a national calamity is expected, or the defeat of an army, should the tribe happen to be at war at the time. It is supposed that an old woman who has always been faithful to her husband has power over fire, and that should a village take fire her presence will stop the flames. Such women are, however, few and far between. When several deaths occur about the same time in one family, it is thought to be due to falsehood or perjury on the part of one of its members. It is very unlucky for a bride to pass under a large tree or to cross a broad road unless she wears an amulet to protect her from the zittan.

Cups made of rhinoceros horn are supposed to detect poison in water, beer, or wine, the fluid changing colour; to give one of these cups to a friend is the highest honour that can be paid to him.

(I think this idea must have been derived from the Arabs.) Twins are supposed to be very lucky, especially girls; they are believed to bring good fortune to the whole village.

Crimes.—Wilful homicide is considered a great crime. The murderer is followed by the friends of the deceased, then tried by the chief, and the invariable sentence is death; neither he nor his friends can by any possible means evade the immediate execution of the sentence. There is no definite executioner, and, with the exception of the puggee (who may never shed blood), any bystander may be called upon to carry out the rigour of the law. Should the person whom the chief orders to undertake the office of executioner refuse to do so, even if a relation or friend of the criminal, he is compelled to pay a fine of two cows. The usual method of execution is as follows:—The murderer's hands are tied behind his back, he is made to kneel down, and is then struck on the back of the neck with a heavy knobbed stick. Another less common plan is to call on a party of men to pick him up and drop him head foremost on the ground, and to repeat this until his skull is completely smashed. This method is called "breaking the water melon," as that fruit is broken by being thrown upon the ground. If an aggravated murder has been committed, or the murderer has killed more than one man, or has tried to escape from or fight with his pursuers, he is slowly beaten to death. The criminal's friends are obliged to bury him at once, at a considerable distance from the village and cemetery; no prayers may be said at his grave, nor may the grave be marked in any way. If a man kills another accidentally he is tried by the chief, and has to give a full account of the circumstances which ended so disastrously. If he has no witnesses to confirm his story, he is required to take an oath on the *Koran*, or on one of the ancient religious books of the Fors; he is then kept for a week in prison, and if none of his relations die in the meantime, he is declared innocent and set at liberty. He is then expected to call together the friends and relations of the deceased man, and to express his sorrow for what has happened, after which he is treated in a friendly way by them, but on no account will they eat out of the same dish with him. Suicide is unknown in Darfur.

If a man wounds another in hunting or in the games no notice is taken of it; if on other occasions, a fine must be paid. If two men quarrel and fight, they are not punished, unless either is hurt on the head, in which case both of them incur a fine. If a rape should be committed upon a very young girl, a circumstance of extreme rarity, the whole of the offender's cattle are confiscated. If a man runs away with a girl, both his and her parents have to pay a fine to the chief. Seduction in our sense of the word is unknown. If a woman is caught in the act of adultery her husband is allowed to kill the man and beat the woman. It is very common for a married woman to fall in love with another man and ask him to kill her husband; if this gets found out, as is usually the case, both the guilty parties are executed. If a man sets fire to another man's hut, he has to pay all damages; he also gets a good beating, and must pay a fine to the chief, as the fire is so liable to spread through the village. If a person steals, he receives a thorough beating for the first two or three offences; but if repeated, one of his hands is cut off, the arm being made fast to a log of wood and the wrist-joint divided. If a person insults a puggee, or in any way injures him, he must pay a fine both to the chief and to the injured priest. Lying is held to be a great crime; even the youngest children are severely beaten for it, and any one over fifteen or sixteen who is an habitual liar suffers the loss of one lip as a penalty.

When several of a family die, it is supposed to be the result of lying on the part of the father, or rather a denial of an accusation of lying while placing the hand on the *Kitab*, the falsehood having been really committed. On such occasions the priest says—"If you are not speaking the truth may God turn against you," and then if deaths in the family soon follow they are thought to be God's judgment. To obtain His mercy a white pigeon is brought to the puggee by the man, accompanied by his accuser; the priest kills the pigeon, puts some of the blood on both accused and accuser, and then the pigeon is carefully put away and not eaten. This seems to be the nearest approach to sacrifice that obtains in Darfur.

On the whole, Darfur is singularly free from crime, adultery and inciting to murder in order to get rid of a jealous husband being the most heinous offences.

Morals.—The words used to express right and wrong are those which denote also good and bad; namely *Tulai*, good, and *Gettee*, bad. A good man is one who is truthful and honest, brave, and kind to animals, who bears pain with fortitude, and is loyal to his neighbours and his sultan; the bad man is the reverse of all this.

The Fors are rather wanting in vivacity, and are somewhat sluggish in action. They are, however, very quick tempered, and even passionate and brutal when excited by drink. They are very avaricious and little given to hospitality, except from interested motives. They are not very cleanly. They are very intemperate, and drunkenness is not considered either sinful or degrading.

The women are associated with the men in all their occupations, save in war; but their presence does not appear to have exercised any softening influence upon the character of the men.

The men are not much given to jealousy, unless with very good cause, and therefore the women do not avoid the society of men, and girls and even married women think nothing of passing the night with men who please them. They wear bells on their ankles and bangles round their necks and waists, and perfume themselves extensively in the hope of attracting lovers. Before marriage the young men and women are most lax, and indeed a father would be held up to public ridicule, if not well beaten, if he attempted to preserve his daughter's chastity. Indeed, excessive ugliness or very bad health could alone secure to a girl her virginity.

At markets, at feasts, and at dances, the young people have as much freedom as they could possibly desire; the men visit their sweethearts at night, or the girls go to them, and it is not considered immoral. If, however, a father has any strong objection to any particular suitor for his daughter's hand, he may forbid him to visit her, and give him a thrashing if he catches him in her hut. Adultery is considered a purely personal injury, and no sympathy is shown by outsiders to a man who is not brave enough to kill the rival in his wife's affections. Should he ask for help, the only reply would be—"You cannot be a good husband or your wife would be satisfied with you." A police of eunuchs was once instituted to put down this open immorality, but it totally failed and was soon given up. The chiefs and rich men have all fairly large harems, and usually have one or two eunuchs, who are slaves, to look after their women. But notwithstanding this precaution, the women do pretty much as they please, for either young men are dressed up as women and smuggled into the harems, or the women steal out at night to carry on their intrigues.

It is not considered right to rob strangers, but the chiefs wink at this offence, and the stranger runs but a poor chance of obtaining justice. Cowardice is regarded as a very grave delinquency, and if a man ran away during a battle his wife would be entitled to a divorce, and no one would marry either his daughters or sisters.

The virtuous side of the For character may be summed up in three words: they are industrious, brave, and remarkably truthful.

Slavery.—The Fors are not large slaveholders, and they do not themselves make slave raids; but they are permitted to capture slaves in war. The chiefs and the very rich people occasionally buy slaves from the Arabs, who are constantly passing through the country with their slave caravans, but it cannot be said that a slave population exists. A good number of eunuchs, who are also slaves, are employed by the chiefs. They are treated as confidential servants, and often attain great wealth and influence. Some of the most influential of them marry, in order that they may appear to have a family. The few slaves who are found in Darfur are well treated; as a rule they are permitted to marry amongst themselves, but some are treated as concubines. It must be remembered that a good number of the Fors have been enslaved themselves by their Arab conquerors.

Marital Relations.—I have described the marriage ceremonies in another place. The woman enters into the man's family circle after marriage. In a first marriage, when the contracting parties are still young, they are compelled to remain in the bride's father's seriba until the first child is born. When a man marries a second or third wife this custom is limited to a week or two. A man may have as many wives as he can afford to buy and keep, but as they are very jealous of one another, they are provided with separate huts in different parts of the village, or even sometimes in separate villages. It is this custom, combined with the large harems of the chiefs, which induces the very lax morals everywhere met with. The first wife married is the chief wife; her children take precedence over the children of others. A man is expected to visit his wives in regular rotation, but the chief wife enjoys the society of her husband for a fortnight, whilst the others must be content with only a week at a time. Concubinage is permitted, but seldom occurs, only a very few slaves being held as concubines. Polyandry is not permitted. There is no class of prostitutes. A man may not marry his near relations, and it is considered better that he should marry out of his own village. But many of the young people become engaged at a very early age when thrown together in tending the cattle. A mutual understanding exists between the young people, and it is only when other young men begin to pay marked attention to the girl that her accepted lover goes to her father and asks his permission to marry her. Such permission is usually given, and they exchange presents before their assembled friends; if they met with a refusal they would probably elope, and then the parents on both sides would have to pay a heavy fine.

The presents mutually given are kept as great treasures, and if any evil befall the separated lovers, they console themselves by saying (pointing to the charm)—"Never mind, I am engaged to so-and-so." The engagement lasts generally for a year or two, and during this time the young man is not allowed to speak to or to visit his intended's parents; should he meet them in the road, he must try to avoid them; he may however visit his *fiancée* at nights as often as he chooses. On arriving at puberty every girl has a separate hut built for herself. From what has been said, it is obvious that the relation of husband and wife in Darfur is not of a very satisfactory character.

Mythology.—Although songs and stories are handed down by tradition in Darfur, the people have no bards or story tellers by profession.

The following are specimens of their stories or fables:—

"Upon a certain day, many years ago, some boys were in the fields watching a herd of cattle. A thunderstorm, accompanied by much rain, came on, and the boys drove the cattle home, but in their haste they lost a cow belonging to an Arch-Barr. The cow happened to be a valuable one, so as soon as the rain ceased the Arch-Barr set off to seek for it, and during his search he was obliged to cross a very broad swamp. As is usual after a shower of rain, all the frogs in this swamp were singing (croaking). The Arch-Barr waded through the swamp, when one of the frogs called out—'Arch-Barr you've gone too far, your cow is on this side of the swamp;' so, thanking the frog, he retraced his steps, but had no sooner returned than another frog called out to him—'Arch-Barr your cow is not there, it is just by me;' but when he reached that frog he discovered that he had been misled again. This went on for some time until the poor man got quite tired with wading backwards and forwards across the swamp, and the frogs laughed so much at his expense that they had not strength to call out to him any more. Seeing that he had been made a fool of, he tried to kill one of the frogs with a stick; but this angered them, and they cried out that they would kill him, at which he was so frightened that he ran away. On his way he met another frog who told him the real whereabouts of his cow, and he drove it home at last in triumph; but his jubilation was short-lived, for one of the frogs hopped after him to the village and told his friends how they had made a fool of him. Everybody laughed at him and gave him the name of Sandara (the frog), which nickname clung to him to his dying day." It is said, too, that his sweetheart lived on the other side of the swamp, and each night when he went to see her he was laughed at by the frogs and insulted with many rude remarks.

"Once upon a time an elephant and a camel were great friends, and they agreed that they would plant a large field with dhurra; this they did, and then they got a hare to watch and take care of it until the time of harvest arrived. The dhurra was then gathered, thrashed, and winnowed, and two great heaps were formed—one of grain and one of husks and stalks. When they began to divide the grain they had a dispute, and it waxed so hot that their friendship vanished and they decided to fight for the biggest share; so each went away to collect an army. The elephant gathered together all the large animals into his army, while the camel enlisted the services of the small animals. Now the captain of the camel's army, although so small, was very wise and cunning, and he said to the camel—'Unless we cheat the big animals we shall not be powerful enough to beat them.' So he told the camel to lie down on the ground, and all the little animals covered him up with a heap of dhurra stalks, with the exception of one knee, and told him to lie perfectly quiet and still. They then all ran away, and hid themselves at a little distance to watch for their big enemies. At last the elephant and his army arrived on the scene, and were much surprised to find no one to fight with. However, one of them, with eyes sharper than the rest, noticed the camel's knee, and said—'What is this?' and went up and gave it a good bite, at which the camel roared out with pain, and this so frightened the elephant's army that they turned tail and ran away. The camel's army then left their hiding-places and pursued the fugitives, coming up at last with the elephant, who was quite alone and unprotected, and whom they killed, and then devoured. By this means the camel obtained all the corn for himself; he thanked his army very much, and paid them well for the great service they had rendered him. Little people can beat big ones if they are only sharp enough."

"One winter day a hyena climbed up a tree to gather some leaves for food. After he had collected a great many, he saw below him a little lamb who had wandered from her mother and was all alone. At this he came down so quickly that he lost all his leaves. When the lamb saw him she was very frightened, and said—'Hyena, what do you want?' he answered—'I want to eat you up.' The lamb knew it would be of no good to run away as she would then very soon be caught, so she thought of the following plan to save her life. She said to the hyena—'There is a pool of water a little way from here; before you eat me you must go and get your mouth full of water,' and the hyena went, and the lamb went off as fast as her legs could carry her towards the village. After she had proceeded some little distance on her way, up came the hyena with his mouth full of water. 'Now you can't eat me,' she said, 'because your mouth is full of water.' 'Oh yes,' said he, and in so saying the water was of course spilt. Then replied the lamb—'Now you certainly can't eat me, because you have no water in your mouth,' so he turned and ran away to get some more. On his return he found the lamb just entering the village, and when he followed her, she turned and said—'Now you can neither eat me with your mouth full or empty, for I am safe,' and with this she jumped into the seriba, and the dogs came and drove the hyena away. So the lamb was saved by her cunning, and the hyena was very angry because he had lost so much time and also his leaves, for when he came to the place where he had left them the wind had blown them all away."

The following story of the rabbit and the hawk (?) is rather long, but as it contains a good many different ideas I think it is worth repeating :—

"A rabbit and a hawk once had a cow as common property ; they used to take it in turn to watch this cow while grazing. The rabbit is a very deceitful animal, and, liking milk very much, on the days when he had charge of the cow he milked it and drank the milk before driving the cow home. The hawk was honest, and on the days when he drove it home there was always plenty of milk for both. Not content with obtaining most of the milk every other day, the rabbit thought of a plan to deceive the hawk still more, so said to him—'It is not good for you to drink the thin milk, but it is good for me, so if you will make a hole at the bottom of your milking pot, I will place mine under it ; then the thin milk will flow into mine, and you will keep the thick milk.' The hawk agreed to this, but of course all the milk ran into the rabbit's bowl, and the hawk retained the froth alone, which vanished when he put it on the fire to boil. The hawk could not understand this, and so went to ask the rabbit for an explanation. The latter said—'Oh you silly bird, you must stop up the hole in your pot, and put some water in it before you place it on the fire to boil, and then you will get good milk.' Next day the hawk did so, but found the milk very poor, so went to the rabbit for a taste of his milk. He said it was in his hut and he would go and fetch it, but he brought out a bowl of water to which he had added a few drops of milk. Thus the hawk was deceived again, and was very angry with the cow for giving such poor milk, on which the rabbit suggested that he should drive her to new pastures a long way off, as that might improve her milk. The hawk consented to the rabbit taking the cow, on condition that his son should accompany him. After proceeding for some distance, the rabbit made up his mind that, as he could deceive the hawk no longer, it would be best to kill the cow, so he killed the hawk's son and the cow, which he devoured. He then went home and told the hawk that he had left the cow with his son, and that they would return in a few days, but he was very much afraid of the hawk finding out what had happened, and thought of the following plan to escape from his vengeance :—Far, far up in the sky, so far as to be invisible to mortal eyes, there is a place where the animals meet to dance and sing and to amuse themselves, and to this place the birds carry the four-footed animals. The rabbit therefore proposed to the hawk that they should go up and amuse themselves until the cow returned, and to this plan he consented, only stipulating that they should first dress themselves nicely, and perfume themselves well, in order to be received with joy and to find mates quickly amidst the merrymakers above, and he asked the rabbit to prepare him a nice scent. The latter, however, prepared him a kind that smelt exactly like the 'kurkinja' (a small animal that lives in holes in the ground, and whose smell is very much disliked by the Fors). This scent the hawk placed upon some glowing embers, and fluttered about in the smoke until he was thoroughly perfumed. He then took the rabbit on his back and flew up to the animal's paradise. After they had been there some little time and had become acquainted with the denizens of the country, the rabbit requested permission to sing a song. On this being accorded him he procured a drum, and began to sing—'Oh! the hawk stinks like a kurkinja! Oh! the hawk stinks like a kurkinja!' at which everyone laughed, and cried out—'Yes, yes, he does.' This much enraged the hawk, who flew away. As soon as the rabbit had made sure that he had really gone, he asked his new friends to make a long rope and to let him down to earth again. This they did, and he told them that directly he shook the rope they were to let it go. But he mistook his distance and shook it too soon, by which he got a good fall, and coming in contact with a thorn bush a thorn went right through one of his ears. The rabbit was very angry at this, but the thorn bush said—'Never mind,' and gave him some gum, whereat he went away. He soon found a bird sitting on a nest of eggs, and gave her the gum, which she ate; his anger was aroused again, and to appease him she gave him an egg. He then soon came up to a group of boys taking care of some sheep, and gave them the egg to look at, which they dropped down and broke. Once more he was very angry and demanded a sheep, which he got; and this he drove before him until he came to a village where the people had many cattle. He showed them the sheep and they killed and ate it, he partaking of the meal. After they had finished, and all had washed their hands, he told them that he must have a cow in exchange for his sheep. This they refused, but he made such a noise that at last they made him a present of a big fat bull, which he took into the forest near by. He killed and ate it and afterwards stuffed the skin, and came back to the village and asked them if they would exchange it for a camel. They consented, and he mounted his camel and rode with them to the place where the stuffed bull lay. He told them to beat the bull and it would wake up, and then rode off and vanished in the distance. When the villagers found out how they had been treated they were very incensed against the rabbit, but he took care never to come that way again."

This story is told to show how deceitful the rabbit is, and to warn people that if their path is crossed by one they must be very cautious during the whole of that day, or they will probably be deceived by some one.

War.—A class of regular soldiers exists in Darfur, and they are called dalimars. They are in the service of the chiefs, and any strong young man may enlist in their ranks, but they receive no regular pay. They are liable to be called on for service at any time, and they then receive proper rations of food, and at the close of a war they get presents of damoor cloth and grain. They all possess land just as others do, and in times of peace cultivate it and support themselves and their families. All the dalimars of a district reside at the chief's headquarters. They are divided into two classes; the one is composed of well-to-do men, the other of common soldiers. The former live in separate huts with their families, in an enclosure on one side of the chief's quarters, and are treated by him with much respect and consideration. Notwithstanding this they do not seem to be very contented, and the puggees often have to bring their influence to bear on them to settle disputes between them and their chief. The lower class soldiers live in long sheds on the other side of the chief's enclosure, and a strong grass wall divides the two classes. A similar one forms an enclosure all round the chief's village, and outside this again a strong hedge protects the place from attack by men or intrusion of beasts. Between the two walls are gardens, but the principal gardens and the fields are outside the seriba.

An under chief lives in a hut at the door of each division, and is responsible for the gate being properly guarded, as watch is kept there night and day. No one can go and speak to the chief without first having his business ascertained by the under chief. The lower dalimars are very badly treated by the upper class dalimars; most of them drink to excess, and a good many chew tobacco. The dalimars are exercised in throwing spears, &c., outside the village, on ground set apart for the purpose. A young man may become a soldier when about 15, but boys are allowed to go and live with the dalimars long before this age if they have friends among them, and their parents have no objection to their following that calling when they grow up. A sub-chief is responsible for the whereabouts of all the dalimars, and they have to leave their names with the gatekeeper whenever they go out of the seriba. These gatekeepers have a remarkable power of remembering names and faces, and are able to give the chief the names of all absentees, who sometimes may number a hundred or two. Although the dalimars form the nucleus of an army, they by no means represent the entire force of fighting men, for every man capable of bearing arms is required to fight when necessary. The dalimars are employed very much as a police force in time of peace; should war break out, they are sent round to all the villages to collect those who intend to fight, and to tell them to assemble on a given day at the head chief's seriba. When all are collected the march begins, and definite positions are occupied during the march by the various constituents of the army. The chief leads the procession; on his left hand is the second chief at the head of the rich dalimars; on his right, the third chief at the head of the lower class dalimars. To the left of the rich dalimars march the villagers, led by their respective headmen. The chiefs and the headmen often ride on horseback, but they do not like fighting on their horses (this does not apply to the cavalry). The distinctive dress when at war is a white girdle of damoor cloth wound round the waist. The chief does not wear his unless walking, but uses it as a saddle-cloth. If a man distinguishes himself greatly by bravery in battle he is often made a chief, and such chiefs are more respected than the hereditary chiefs. The minor rewards are by election to be sub-chiefs or headmen of groups of villages. There is no punishment for cowardice, as the disgrace is in itself a sufficient penalty; the news of it soon spreads, and is made the subject of sarcastic songs at the village feasts. The Fors believe that if they are very brave in battle they will have a white horse to ride upon in the next world. Duels are common in battles, and are often resorted to in order to regain the favour of the sultan.

As soon as the army nears the enemy's country the order of marching is slightly altered. A vanguard and a rearguard and right and left wings and centre are formed; skirmishers are also sent out (Sandanger) in couples to look out for the foe. The attack is often delivered from various points in order to throw the enemy into confusion. They choose their camps if possible near a river or by wells, and seribas are formed for their protection. The people encamp in exactly the same positions they occupy when at home, so that there is no difficulty in finding a given man when wanted. Fires are allowed in camp, unless they are very near the enemy, in which case they are forbidden to talk loud or to sing. All sleep on the ground, their girdles (mulpa) being spread beneath them. In marching they are not obliged to keep step. The arrangements as to scouting and the various divisions of the army are made by the heads of the villages in consultation with the sub-chiefs. The only baggage carried is the food, which is taken by each man in a skin bag carried on the back, being hung round the neck by a cord. Camp followers are not allowed. The war songs are numerous and spirited, and are sung in camp, on the march, and sometimes during the fight itself. The particular cry in danger is "Ku-ru-ru." When in camp, war dances are sometimes performed for the purpose of cheering the sultan or chief. They advance in rows, each man holding a spear aloft with his right hand and trailing another in his left. On approaching the chief they kneel down on one knee singing all the time an inspiriting song, and on rising they touch the ground with the tips of their spears. They then move off, and are followed by successive rows, who go through the same manœuvre. The same thing is done by the dalimars to the heads of the villagers and by the villagers to their own headmen. Camp life appears to possess great charms for the people, and for the time being they appear to be much drawn together, and to avoid quarrelling.

There used to be about 3000 cavalry, with headquarters at El Fascher; but their number is now much reduced.

During a war the women are sent to places of security, and do not accompany the men.

The Fors do not like to encounter their enemies if the latter are on a height above them. In such a case they do not stop to throw spears while advancing, but go rapidly forward and try to dislodge the hostile ranks from their position. One of their favourite means of warfare is to surprise their enemy by getting round them through a wood or a valley, or in some such way to take them unawares. When about a mile from the foe the army is often divided, the smaller portion making a direct advance, while the others form a circuit and take the enemy in the rear, the latter being meanwhile deceived by those who are attacking them from the front pretending to run away. The enemy is also very often attacked at night, the army advancing very quietly and throwing a spear with a light tied on to it so as to strike one of the enemy's huts. Sometimes they approach the hostile camp just before dawn, and lie down under the seriba until the people begin to get up, when they rush in and easily gain a victory. At other times they fire the seriba at different points, and when the whole is ablaze and the enemy run out the latter are impeded by rows of spears firmly planted in the ground slanting towards the seriba. They are careful to prevent the enemy attacking their villages during their absence by means of scouts, who are very clever. In retreat they keep together, and halt at the sound of the drum. Alliances are frequently made with other tribes for mutual defensive purposes. The villages are all surrounded by a strong hedge composed of stakes and thorn bushes, 7 or 8 feet high and 12 broad, with flat tops. In the Gebel Marah district earthworks are also employed as a means of defence. If the Fors are being attacked by an enemy they often light fires in their village in order to deceive their foes, and then retire to a short distance, returning as soon as the enemy are well inside the village; by this means they hem them in and prevent their escape. The wars in which the Fors engage are generally of short duration, one or two battles being usually sufficient to settle their disputes. Prisoners taken in war are sometimes kept for a long time; they are chained and confined in strong huts and are compelled to work, but they may be ransomed or exchanged. Unless they misbehave themselves they are well treated, but any one trying to escape is killed. After conquering another tribe the Fors do not stay and govern the country, but after collecting together all that is movable they burn the villages and retire; the main object in war is to kill or capture the opposing chief.

Weapons.—The weapons used by the Fors are spears, bows and arrows, throwing knives, swords, a few guns, clubs, shields, stones, and two machines for throwing large stones and javelins. Bows and arrows are not very much used; the bows are very strong, about 4 feet long, and are strung with the sinews of animals; the arrows have very varied barbed heads, and are made so that the head shall remain in the wound when the arrow is withdrawn; they have no feathers, but are notched for the string, and are ornamented with bits of iron wound round them. Six spears make a complete set, five of which are light, so as to be easily thrown; the other is much heavier, and is used in hand-to-hand combat. There are many different shapes in use, some plain and others barbed. Shields are made of bulls' hide; they are oval and convex, and from 3 to 5 feet long. A wooden rib runs down the centre inside, in the middle of which there is a wooden handle, which is grasped by the hand. Most of the swords in use are imported; they are straight, two-edged, and used for both cutting and thrusting. The throwing knives are curiously curved, and are thrown with unerring aim, as are also stones, the latter being much used, especially from heights such as occur in the Marah district; they are also thrown with a split stick. The machines for throwing heavy stones, and the catapults for javelins are well and dexterously made. I do not know when they were introduced into the country, but they have been there for hundreds of years if tradition be correct.

Government.—The Fors have had a long hereditary line of despotic sultans, the last of whom, Haroun, was killed by the Egyptian troops in 1881, after I visited Darfur. Until this time the sultans lived in great state, and the Arab tribes who had encroached upon their country had been compelled to pay them taxes in order to enjoy their protection. Wherever the sultan lived his residence was called El Fascher, and it is only since the Egyptians conquered the country that El Fascher has become a definite spot. Darfur was divided into five large provinces, severally ruled by a high dignitary of state, and each of these provinces were subdivided into small districts under the management of *shartays* or local governors. All these rulers are hereditary, but the succession goes to the youngest son, who also inherits the chief's private property. The local government is carried on by each chief independently, but they are all responsible to the sultan for maintaining order in their respective districts. The people are not allowed to appeal from the chief's decision to the sultan, and their only means of redress under oppression is to rise against their chief, which action is usually followed by the sultan's interference, who either compels the people to submit, or removes the chief, as the case may be. The chiefs are compelled to pay certain taxes to the sultan, which they must present in person. No one is allowed to speak to the sultan directly, but only by means of a go-between.

Laws.—Any person may occupy as much unappropriated land as he pleases without paying for it. Encroachments on land are prevented by thorn hedges, broad paths, or ridges of earth, which are employed as boundaries. Game is not preserved; it may be killed whenever found. If a man dies without heirs, or leaves the country without giving up his land to a successor, it may be reoccupied by any one who chooses. Land is either left to daughters or to the youngest son, that is, if they are still infants, for their support until they are married; it is subsequently equally divided amongst them. The elder sons are supposed to be able to occupy land for themselves. As a rule, a father leaves nearly all his personal property to his youngest son. If he should die without any special orders to this effect, the first wife's children draw lots for the property, and thus divide the cattle, grain, &c., between them. Smaller parts of the property, however, are in the hands of the other wives, for their own support and that of their children, and these goods and cattle are divided amongst their children on the father's death. There is no provision made for the widows, as they mostly marry soon after their husband's death. When a man is thought to be dying he sends for two puggees to hear his will, and they are charged with the carrying of it out. If a man dies without a puggee being present, except in war, he is thought to die like a dog.

The chiefs and puggees are the judges. Persons who are waiting for trial are chained and kept in a hut by themselves. Strangers are never put to death except for murder. Suspicious-looking strangers entering a village are confined in a hut until they can give a good account of themselves. Failing this, they are escorted by two men outside the village and sent away. For other laws, see the paragraph on *Crimes*.

Hunting.—During the dry season the people devote much of their time to hunting. While spinning their cotton in the village yard the hunting parties are planned and arranged, chiefly by the young men. Their leader, generally the best and most experienced hunter, is called the *ageet;* he settles the district to be hunted in, and lets the people in the neighbouring villages know when the hunt is to take place. At the given time the several parties meet there, each led by their *ageets*, and blowing their horns, to hasten those who are late. When all have arrived at the place of meeting the chief ageet takes the supreme direction, and arranges everything connected with the hunt. After it is over they reassemble at this place, and the *ageet* tells them where the next hunt is to take place. These hunting parties are not at all identical with war parties. There are no rewards given to successful hunters; each man hunts for himself, and retains his own spoil; if a man has more game than he wants, he gives to his friends or sells the remainder. If several shoot at the same animal, it is divided between them. Very few serious quarrels occur while hunting. There are no laws for the preservation of game, and they shoot everything that comes in their way; the whole country is free for all to hunt in, even should the hunters belong to a neighbouring tribe. The skin and horns of an animal belong to its slayer. The meat is preserved by drying it in the sun or smoking it over the fire. The hunting weapons are used for war too, but not as tools. They use spears, and bows and arrows. They can hit birds on the wing. Dogs are trained to hunt. The Fors very often fire the forest, and then place themselves in a favourable spot, so that the frightened animals may fall an easy prey to their spears. Guinea fowl are driven into nets; snares made of string are used for catching birds. Game is carried home in the hand or on the shoulder, or on a pole carried between two or four people. Should the animal be very large it is cut up on the spot and taken home in pieces, none being left to waste. Sometimes small hunting parties are made up of horsemen, who go long distances in search of game; the horses are used for hunting the wild boar and for running down ostriches. All other animals are attacked on foot. Should the chief *ageet* of a district die, the best known hunter is appointed in his place.

The wound of a poisoned animal is cut out immediately.

Boys go hunting by themselves; they catch birds, mice, rats, guinea fowl, and hares. Guinea fowl and a kind of partridge seem to be the only animals taken alive and kept. Their eggs are also taken and hatched by fowls.

Traps.—The Fors resort to various means of trapping game.

A stout post is placed in the ground on either side of a path frequented by animals going to drink; a cross bar is fixed at the top, on which a slip noose is fastened which hangs almost to the ground; into this the animal runs and is secured.

Small holes are dug in the ground and covered with twigs and grass. Around them slip knots are arranged, their ends being made fast to a heavy log of wood or the trunk of a tree. The animal, walking over these holes, gets its feet entangled, and while trying to shake them loose tightens the noose and makes sure its captivity. Sometimes large animals drag the block of wood with them, thus leaving a trail for the hunters to follow up.

A trap for lions is constructed as follows:—A large hole is dug in the ground and covered with mats, which are again covered by earth. A tall pole is placed in the middle of the hole with some meat suspended at the top; when the lion attempts to jump up to the bait, it of course falls into the hole.

A tall pole is fixed in the ground with a bait at the top; around it are placed spear heads firmly embedded in the ground, with their points upwards. The animal jumps to get the bait, and falling back impales itself on the spear points.

A stone house is built, with one end open. A swinging door is arranged to close it when an animal has entered for the bait which is placed at the opposite end.

A basket trap is employed for birds. One edge is supported by a stick, so arranged that when the birds enter the basket imprisons them.

The roof of a big hut is sometimes lightly supported by stakes, to one or two of which a rope is tied. A man conceals himself at some distance from the hut, holding the ends of the ropes in his hand, and when animals enter the hut for the bait which is placed there, he pulls the ropes and the roof falls over them. This contrivance is sometimes placed over a small stream where animals come to drink.

Nets are also used for trapping birds.

Fishing.—Although the For women do not take part in the hunting, they join in fishing; in fact, the whole population in the western part of Darfur fish, and consider it fine sport. They fish with the rod and line, with baited hook; they spear the fish, and they catch them in wickerwork traps. Fish are also netted, but this method is rarely employed except by the blacksmiths, who always fish by themselves. Small pieces of the bark of a bitter tree are sometimes thrown into the water; the fish eat them and are poisoned. Dams are also constructed in the river, from which the water is subsequently drained and the fish caught by hand. When caught, the fish are cut open, and then smoked on a stand over a fire or dried in the sun. The harpoons are made with movable heads, to which a line is attached; they are usually barbed. As soon as the fish is struck the head becomes loose and the fish is played by the line attached to the head; this same remark applies to the hand spears. Bows and arrows are used by the boys for shooting fish; the arrow has a line attached to it, but the heads are not loose. Fish are not preserved alive.

Trade.—Men devote themselves entirely to no trade save war, with the exception of the blacksmiths, and in war alone are the services of the women dispensed with. All other employments are followed by men and women alike.

The following articles are manufactured:—Damoor cloth, shirts of damoor, caps of damoor, leathern sandals, water skins, leather bags for carrying grain, earthenware, string, mats, basketwork, rough spinning wheels and looms, shields, spears, bows and arrows, bracelets and rings, and iron implements used in cultivation. A few of the Fors are very expert in the manufacture of filigree work, and in ivory turning.

Damoor cloth, wheat, and dhurra are employed as the principal articles of barter, but almost everything is used for exchange as occasion serves. All the Fors are very industrious, in fact they are the most industrious tribe I have ever visited. It is quite a pleasure on entering one of their villages to see the whole population, men and women, young and old, engaged in some useful occupation. Work is paid for with dhurra, food, and drink. The people consider it to be an honour to work for the chief without pay, but he provides them with food and drink.

The blacksmiths are the only class of special workers who do nothing but follow their own trade. They are a class quite apart, live in their own villages, enjoying a very bad reputation, and being looked down upon by the rest of the community. They are great drunkards, and are continually quarrelling and fighting, and the dalimars have to be constantly employed in keeping order in their villages. They are the only men who take apprentices.

Strangers and very poor people are sometimes employed by the rich, and are paid in dhurra and cloth, besides receiving their food.

Exchange of goods is carried on with several of the surrounding tribes, and with the Arabs. Markets are held once or twice a week at convenient places near several villages. There is a free exchange of food, cattle, tools, arms, ornaments, &c. Beer is also sold, and disputes and fighting in the market are of common occurrence. A few dalimars are usually sent there to keep order, and they levy a small toll on the villagers. Any one may engage in trade, and most people have something to sell. Credit is sometimes given to people living in the neighbourhood; should they not pay, the dalimars are sent to exact the debt, and the debtor must also pay them for their services. All people have a right of way so long as they behave themselves. There is no hongo. People go in companies to the markets, but each trades on his own account; this applies also to fishing and hunting expeditions. Goods are carried in skin bags or in mats upon their heads or backs. Camels, donkeys, and oxen are also used as beasts of burden. There are no porters proper, but sometimes men are hired to carry things. There are no boats, nor is there any river navigation.

Ancient tools, weapons, knives, and ornaments are sometimes found on the sites of deserted villages.

The Fors are not at all wasteful; dry bread, for instance, is kept after being dried in the sun, and when needed for use it is chopped up fine and eaten with water. Remnants of food are not thrown away, but given to the dogs. Meat and fish are cured and stored, as also dhurra and dried vegetables.

People are rich or poor according to the number of cows they possess. A poor man often becomes rich by working hard, and thereby accumulating presents of cattle.

Money—Exchangeable Values.—A good bull is worth fifteen sheep, and some favourite bulls are sold for not less than thirty sheep. A cow is worth fifteen young goats; a he-goat, three sheep. A sheep values six hoes, eight or nine common spears, or three good spears, or one damoor cloth.

Wedding dowries depend much upon arrangements made between the parents, and also very much upon the class of the contracting parties and the beauty of the bride.

No beads or cowries are used as money, the standard money being damoor cloth, but in the large towns imported cloth and Maria Theresa dollars are used. Forty small pieces of damoor cloth, a foot long and 4 inches broad, equal in value one white cloth, two of which equal a dollar, a small blue cloth being used to represent half a dollar. The standard white cloth is called a *tob;* the blue cloth, *faradieh;* and the smallest pieces of cloth, *rubieh.* The prices at Dara, when I was there, were as follows:—An ox, from 3 to 6 dollars; a sheep, three-quarters of a dollar; a goat, half a dollar; a good riding camel, 50 to 70 dollars; a pack camel, 25 to 30 dollars. A horse cost 50 or 60, though some horses and hygeenes (riding camels) fetch as much as 300 or 400 dollars.

The taxes then paid to the Egyptian Government were in tobs or grain, and the inhabitants were obliged to provide camels and oxen for transport, but for these they were paid at a fixed rate in *tobs.*

Weights and Measures.—The standard measures are two sizes of wooden vessels, the largest of which holds about a peck of grain; the other is half this size. Small adansonia fruit-shells are also used; they vary in capacity. Strangers who come to the country to buy must use these measures.

Damoor cloth is measured by the length of the arm, from the tip of the middle finger to the elbow, or to the axilla. If the whole arm is used, three fingers'-breadth more cloth is added, to make this measure double the length of the fore-arm and hand, which latter is the standard measure for cloth. Cloth is also measured on the ground, either by placing one foot before the other or by strides. When cutting out cloth and measuring its breadth, the span of the hand is used, from the thumb to the end of the middle finger, but people with large hands must use the span of the thumb and the first finger. Short distances are measured by strides, and long ones by the sun and a day's journey. Land is not measured. Weights are not used. Two handful of dhurra are considered a meal for one person, and this quantity is supposed to be contained by an adansonia fruit-shell. Counting is performed with ease. Tallies are not used, but for counting high numbers beads on a string or marks on the ground are made use of.

Communication.—The roads in the northern and north-eastern parts of Darfur are simply paths which lead through the open country. In the south, paths between villages are worn by use. No roads are made. Very deep swamps are sometimes rendered passable by grass, stones, and branches of trees sunk into them. The only bridges that are formed are those made by felling trees and placing them across small deep rivers. Ferries do not exist. Wells are kept up in the caravan roads and in the north-east part of Darfur; where water is very scarce, adansonia reservoirs are constructed, which are filled by the neighbouring villagers during the rains, the passing caravans having to pay a tax for the water they use. The pack-saddles which are used for donkeys and oxen are simply pads made of platted grass, and fastened round the animals by a rope or leathern thong. The goods are then slung on each side of the animal. The camel and riding-saddles are exactly like those used by the Arabs.

Pastoral Life.—The Fors are in no sense nomadic, but reside in settled habitations.

No store of hay or any other fodder for animals is kept for winter use. They are all fed on grass in the fields all the year round, whether it is green or dry. Horses and he-goats are allowed corn. In colour the cows are either all black, all white, white and black mixed, red and white, grey, grey and white, dark red, almost black. These and the grey variety are considered the best breeds. All the cattle have beautiful horns; the bulls' horns are generally much straighter than the cows'; if they grow too long they are cut to prevent them breaking off. The cattle are not used for draught purposes, but they are ridden and employed as beasts of burden. They are eaten as well as milked.

The horses are white, grey, or dark brown. Many of them are splendid creatures; they are well-proportioned, and have perfect action. They are very well framed, and some of them are so swift that they can run down an ostrich with ease. The people feed them with great care, as if they get too much corn they become ungovernable. The dark brown horses are nicknamed "dongolwies;" the white and the grey are called "kuruks."

The sheep are large, have very short wool, and fine long tails. The rams have long twisted horns. The wool is only used to stuff saddles. Their milk is used for food.

The goats are very fine animals, with splendid horns; they are black, white, grey, or black and white mixed. Their milk is used, and considered the most nourishing milk obtainable. The goat's hair is not made use of, but the skins of goats and sheep are employed as mats, and also made into bags to carry water or babies in. Sometimes they are used as loin-cloths.

Camels are made to serve as baggage and riding animals; they are also eaten, and their milk is used. They have only one hump; some of them are very vicious. They cannot live in the south-western part of Darfur. Their skins are used for mats, for *extempore* beds, for sandals, and to make ropes.

Two breeds of dogs are found in the country. The best are fawn-coloured, and have smooth skin, short hair, long legs, long curly tails, and erect ears. They are used for hunting and as watch-dogs. They are much attached to their masters. Hydrophobia is not known. The other is a mongrel breed, miserable curs, white or black and white; they act as scavengers, and serve no other useful purpose. There are cats similar to our own, but somewhat larger, with long tails and long silky hair.

Fowls are kept and eaten; their eggs are not often used as food, but usually kept for hatching. Cocks are sometimes encouraged to fight; but if this becomes known to the dalimars the perpetrators of the cruelty are made to pay a fine in damoor cloth. Gelding is not practised.

A trade exists in horses, camels, cows, sheep, and goats. Horses and hygeenes are the most valuable. There are no special cattle markets, but in the ordinary markets a space is set apart for the cattle. Donkeys and horses are trained by being made to carry heavy weights, stones, or sand. If a cow is wild its legs are hobbled, and it is not milked for several days.

An epidemic disease called *rutpoia* sometimes attacks the cattle; it occurs in the hot season, and is very serious and usually fatal. The animals when attacked are either killed or at once isolated; the only cure tried is smoking the animals.

The bits, saddles, and stirrups employed are copied from the Arabs. The cattle are guided by a nose-ring, to which a line is attached. There are no carts. Horses are either hobbled or picketed by a rope tied round their necks, and fastened to a stick buried in the ground or to a stump.

Butter is made as follows:—The evening and morning milk are mixed, and then set aside for an hour or two, after which the milk is shaken in skins until the butter is formed. Butter-milk is much preferred to fresh milk. Cheese is made in the following way:—As soon as the milk becomes sour and the curds form, it is strained through a palm-leaf sieve; a little salt is then added, and the curds are tightly wrapped in damoor cloth, upon which a heavy weight is placed. This cheese does not keep long, but the Fors prefer it mity. Butter is often bought, but the cheese is always made at home, the reason for this being that butter can be washed, but not cheese. The women make both butter and cheese, as also the beer. The cattle are milked before breakfast, after which the boys and girls drive them to their pastures, from which they do not return till about sunset; they are milked again in the evening. Women usually milk the animals, but there is no reason why men should not do so if necessary. Cows, sheep, and goats are herded together. During the dry season the men sometimes drive the cattle to a considerable distance, and stay away for several days at a time. When on these expeditions they do not use tents, but form a simple seriba, to which they return at night; they sleep on the ground on skins.

All the cattle of the village are herded together. Every family must send a boy or a girl to help to take care of them, or if they have no children they must hire help. The children all unite to protect the cattle, and if danger is apprehended men go with them to act as a guard; this duty is performed in regular rotation. Wild animals rarely attack the cattle in the daytime, and if they should do so they are usually scared away by the children shouting. The boys are all armed with spears and bows and arrows, which they know well how to use effectively. Most people have a private shed for their cattle, but in some villages there is a public seriba as well.

All animals are killed by having their throats cut, except camels, which are speared in the neck. Wood alone is used as fuel, the dung being used for manure. Animals are never branded or marked, but are each known by name.

Agriculture.—The whole population are agriculturists. Each member of a family has a plot of land which they can call their own, but notwithstanding this division the land is cultivated by the whole family together. After the ground has been cleared it is hoed with iron hoes having wooden handles. Manure is sometimes mixed with the soil. Sowing is performed at the beginning of the rains. The men make holes in the ground for the seed with stakes, the women, who carry the seed in small baskets or adansonia fruit-shells, drop them in the holes, the children following and covering them with earth. A great deal of attention is paid to the growing crops. Children watch them to scare away the birds; they are carefully weeded, the weeds being collected into heaps and subsequently used as manure. Every one helps at the harvest; the corn is reaped by small knives, and put into baskets which the reapers carry with them; it is carried home in these baskets and stacked near the house to dry. When dry it is spread upon the ground, which has been beaten hard for the purpose, and thrashed and winnowed by the women. The men measure the grain and store it away in the granaries, which have been previously described. Wheat, tobacco, and onions require to be watered, and this is done by irrigation. Most of the fields are at some distance from the village. If a man wishes to enlarge his possessions he chooses any uncultivated ground near; he cuts down the shrubs, which he makes use of to form a seriba round the land, and generally pastures his cattle there for the first year. Hedges are not built as a protection from wind. The Fors have no idea of leaving the ground fallow or of improving it by a rotation of crops.

Games and Amusements.—One of the most favourite games played by people who have horses very much resembles polo, and is played as follows:—A flat field is chosen for the purpose, and a large square formed by a ridge of earth. At each corner of the square inside, a goal is placed, formed of two stones or posts. Four companies of horsemen are formed in equal number, and, if possible, the horses in each company are of the same colour. Each man is armed with a long hooked stick, and two large balls are used. Two men throw these balls in the air three times, and then throw them in the direction of two companies of horsemen, who try to drive them back through the lines of horsemen defending the other goals. The latter endeavour to prevent this, and at the same time to drive the balls through their enemy's goals. Should the ball be thrown outside the boundary, the horsemen may not follow it, but it is thrown in again by the umpires. When both balls have been sent through a goal, the game is finished and commences anew. Much agility is displayed by both men and horses. Sometimes several villages combine to get up a match, which is followed by a supper and a carouse. The game is called *puknun.*

A game called *dadarn* is played by boys. A large heap of stones is divided equally amongst all the players, who sit in a circle. They place the stones on the ground before them, then throw one into the air, pick up another, and catch the falling stone. They then put one of the two stones in a separate place, and repeat the manœuvre until all their stones have been removed, or they fail to catch one. If they have used all their stones, they are allowed to help themselves from their neighbour on the right hand, and then from the neighbour on the left until all are finished. If a boy loses all his stones three times, he has to pay a forfeit; either he must dance or must pinch the tips of each of his fingers, or roar like a lion, or run a certain distance and back again. After this, all the other players give him a few stones that he may commence again.

Another game for boys is played as follows:—A large number of holes are made in the ground in a circle, in the middle of which there is a large hole with four other holes round it. The players are provided with a number of small stones, and they move round the outer circle in turns, dropping a stone into each hole, but taking one up whenever an equal number is found. The boy who has the most stones then puts them into the hole in the centre of the ring, and each of the other players forfeits a stone to him. The four boys who have the next largest number of stones place them in the four holes round the central one, and the best player gives them each a stone. Then the five most successful players play against each other until one remains victor. He has to stand up in the middle and sing, turning round as if on a pivot, while the other boys dance round the outer circle of holes. This game is called *aringari*.

Hide and seek is played, and they call out *kee lu*. It is played by boys and girls together. Sometimes two parties are formed, each having a piece of ground marked off by a circle of stones. The one party hides and the others look for them. When found, the hiders run back to try to get into their ground before the seekers catch them. If any are caught they go to the victors' party.

Another very favourite game is played as follows:—Two parties are formed on either side of the village yard; the leader on the one side has a short stick, which he rubs backwards and forwards between his hands. He stands a short distance in front of his party calling out "kiri kirine daw." One of the opposite party then tries to catch the stick, running across the yard on his tip toes and holding his breath. If he succeeds in so doing, and says "Dang doga pute kora kite" without once taking his breath, he is at liberty to take back the stick to his own side, but if he fails he is detained as a prisoner. When a party has lost several of its members in this way, it cannot gain possession of the stick until each of the prisoners have been redeemed by a successful run. Then a run may be made for the stick, and if it is taken, the opposite side take their turn in running. The opposing parties do all in their power to make the runners laugh, so as to compel them to take breath. They laugh, shout, cut capers, and make sarcastic or joking remarks. This game is played by both boys and girls; the girls are more successful in holding their breath than the boys.

The most famous game among the boys is that of mimic warfare. The company separates into two armies; they then mark off a neutral zone, which must be so broad that the best throwers are not able to throw a stone across it. The captains then order the opposing armies to retreat and gather stones; they then advance on each other, singing and throwing stones as they go until they reach their respective boundaries, beyond which they may not proceed until the whole of their stones are expended. Then, at a given signal, they charge each other with sticks, holding them as if they were spears, but they may not throw them. Many of them fall down as if dead, and the arrangement is, that the side on which most fall should be considered the bravest, and that the others should then retreat, being pursued by the conquerors, who capture a number of prisoners. These they bring back in triumph, with dancing and singing, and forming a circle around them they compel them to dance for the amusement of their conquerors. Then they chase them and let them go.

Another mimic war is carried on in the water. The players divide into two parties and swim against each other, trying to drive their opponents out of the water. Those who are driven out arm themselves with grass and mud, which they throw against their adversaries in the water. These dive to get out of the way, and at the same time try to prevent their enemies regaining the water. When both sides are tired, two captains are chosen to end the play by single combat. If one of these is driven out of the water, or beyond a certain point, the other remains victor; should neither succeed in expelling his opponent, the game is considered drawn.

Sometimes the boys make an artificial ostrich. A long stick is fastened to their backs, having a cross stick fastened just above their heads; upon this framework a piece of damoor cloth is arranged, and this represents the bird, which is then hunted by the other boys and girls.

They also make artificial ghosts in a similar way. Two sticks are tied to the boy's arm, over which a damoor cloth is placed; this he holds over his head, and bends about in all manner of directions. By the light of the fire this has a very grotesque appearance, and spreads consternation among the children.

Another game is played as follows :—A row of boys and girls sit with their legs stretched out, while another boy, beginning at one end of the line, repeats a sentence, singing one word for each leg that he passes. When he comes to the end of his sentence, he touches a leg, whose owner must draw it up; he goes on until one of the players has both legs drawn up, and the latter must then go away and hide. The sentence is then repeated, until all the children save one have gone to hide, when the last boy left must go and try to find them. The boy who touched the legs has to remain as a "touch post" on the ground, to which each child that is found runs, but if caught by the seeker before touching him, he has to aid in finding his companions. One of the sentences which they sing is as follows:—"Kamal dolge-jam kune-bort-plo diu-tier tilgam."

The For children have a good many more games of this description, including a tug of war and leap frog.

Medicine.—When ill the Fors are fairly well looked after, and some of the old women are considered to be good nurses, and are often sent for in illness. Except in cases of small-pox, the patients are treated in the ordinary huts. At times, however, they partition off a part of the hut for the patient's separate use.

Although a good deal of belief exists in the power of charms and amulets, the Fors have also a very decided knowledge of the medicinal properties of many barks, roots, and leaves. They are gathered and stored in horns or jars, and decoctions are made from them when required. Some books exist as to the method of employing these drugs, and the way in which they are to be prepared and partaken of is definitely laid down. Most of them are given in a decoction, but some roots are chewed.

Phthisis is well known. It occurs chiefly among the inhabitants of the Marah mountains. It is called *korlo-koro*, and many people die from it. Headache is treated by allowing butter to run into the nostrils, the patient being placed in a recumbent position. It is said to "grease the brain." I have noticed this custom among the Arabs too, so it may have been introduced by them. Toothache is very rare, and I never saw caries in Darfur, although I must note that my boy has had three teeth affected by it since his stay in England. Pains are treated by rubbing or by cupping if very severe; small iron knives and cows' horns are used in the operation. Ague is not very common, and occurs mostly in hunters who have crossed the Bahr-el-Arab in search of game. It is treated by decoctions made from roots, which act as very powerful diaphoretics. Sometimes the attacks are very severe, and the people seem to be afraid of it. Guinea worm is also very frequently met with in hunters who have been in the Darfertit district. The tumour caused by the worm is poulticed with leaves soaked in water, and tied over the part by a damoor rag. As soon as the worm makes its appearance, it is carefully drawn out and wound round a stick, a little each day.

All fevers are treated by heat. Large fires are made in the huts near to the patient's bed, who either rubs himself with castor oil, or is rubbed and kneaded well by his friends. Warm decoctions of leaves are given him to drink.

There is one drug celebrated far and near. It is said to make women sterile, and in men it causes the testicles to atrophy. It is often given out of spite. I saw two men—one about 40, the other an Arab about 25—who said they had had this drug given them, and certainly their testicles were very small; but I confess I was dubious, though most strongly assured of the power of the drug. An antidote is known by a very few of the magicians, and is very dear. Syphilis is treated by a decoction made of twelve parts of a root to one of pepper, and boiled over the fire for about six hours, water being added occasionally. A small gourdful is taken twice a day, and the patient may eat nothing salt or sour for six days, and must drink as little fluid as possible; then for six days he must eat only bread, and perhaps a little fowl, but no salt; for the next week he may eat a little meat, and then return to ordinary diet. The medicine is taken for twenty days. Slatin Bey told me he had seen twenty or thirty cases thus treated and cured (?). I saw a good number of people suffering from secondary and tertiary symptoms. Necrosis of the skull bones is apparently common. The people say that this disease was introduced by the Arabs from the north many years ago. Persons afflicted by it do not try to communicate it with the hope of curing themselves, as is the case in some neighbouring districts, Kordofan for instance. Inoculation is not practised. A peculiarly virulent form of gonorrhœa, accompanied by cystitis, is very common; the Fors are very noted for this disease. Leprosy and elephantiasis are far from uncommon; the former is said to be hereditary. Ulcers of the leg are not so general in Darfur as among the tribes farther south. Ophthalmia is very rife, but is invariably cured by the application of a lotion made from the root of a shrub. Epilepsy is frequent; girls are more prone to it than boys, in whom it is rare. It is thought to be caused by the afflicted person committing some fault, such as pilfering food, or going into a hut which is under the protection of the Zittan (see above), or committing some offence under a tree in which a Zittan is thought to live. The aura is said to be a peculiar smell which they attribute to the Zittans, and which is usually smelt under trees where they are supposed to reside. When girls suffer from this disease, they hardly ever find husbands, and in consequence lead immoral lives. The priests try to cure them with charms and amulets. The internal medicine which alone is used for epilepsy is as follows:—A puggee writes a few prayers upon a board, the writing is then washed off with water, which is then drunk by the patient. Epileptics are not systematically ill-treated, but their fathers cannot be said to have much affection for them, as they cannot expect any dowry for them. Although I made many inquiries on the subject, no single case of idiocy or mania came under my notice, and the people said that they were very rare. Small-pox is very common. Persons who suffer from this disease are kept strictly isolated; an old woman is deputed to nurse them. She gives a diet of porridge and milk, keeps the hut very warm, pricks the pustules as soon as they are well formed with a thorn, and anoints the patient's body with castor oil.

Wounds heal very rapidly; they are dressed with a pulp made from various roots and barks. Arms are sometimes amputated for disease, but the legs never. The Fors also remove parts of the tongue affected by epithelioma. Splints well padded with cotton wool and fastened by strips of damoor cloth are used for broken bones. A few of the magicians are very celebrated for their dexterity in removing cataracts; they travel round the country, and enjoy a wide reputation, and for successful operations receive very considerable remuneration. Deformities are very rarely seen.

I never saw an albino. They are said to be very exceptional. They are called abortions, as the people believe that they were born before their time. They are mostly beggars, and much despised, as they are said to be very cowardly, silly, and cry whenever they are pinched. They are also said to have little power of smell.

Labour.—As before mentioned, married women have huts of their own, and as a husband does not live with his wife during the later months of pregnancy, she has only to send her children away to her friends to be free from observation. A few of her female friends attend her during delivery. A group of women usually stand outside the enclosure uttering cries to encourage her, but all men are kept at a distance, and it is considered very bad manners for a man or lad to go near a compound in which a woman is in labour; the woman either leans against a wall of the hut with feet apart or in rare cases supports herself from a rope attached to the rafter. Her friends meanwhile keep up the fire, supply her with beer, and from time to time rub her abdomen, and as the child is born they receive it and cut the cord with a knife (rarely, a sharp stone). The cord is never tied, and if it bleeds it is held between the teeth. Cases of difficult labour appear to be rare, and no inquiries could elicit any information of measures taken to aid delivery. Should it be impossible, the woman and child die, for abdominal section is not practised either before or after the death of the woman. The child is washed after birth and rubbed with oil, and then wrapped in damoor cloth. The woman does not bathe but is washed, and she then lies down near the fire; the child is put to the breast as soon as the mother has been made comfortable. The woman is perfectly secluded for a week after the birth of the child.

For some days before a woman expects her labour she abstains from meat, and during the week afterwards she is fed on thin porridge, and eats no meat until the feast is celebrated at which the child receives its name. No superstitious practices take place at the birth of a child.

Ironwork.—Brown hæmatite iron is to be found in great abundance, and used to a large extent, but no flux is employed. The smelting furnaces are about 6 feet high; they are conical, and have at the bottom a number of holes to which the draught from the bellows is led through clay pipes. The bellows are made of clay pots covered with soft skins into which a hollow stick is fastened. Each man works two of them, one with each hand. The ironstone is broken up into fragments about as large as walnuts, and these are placed in the furnace with charcoal in alternate layers. The iron is purified and shaped by long-continued hammering; stone hammers and anvils are alone used. The work turned out is of a very good quality.

Basketwork.—Various kinds of baskets are made, some of open wickerwork but others so closely woven as to hold water. The shapes are oval and round; some are made with lids. The bottom of the basket, which is always flat, is first made and the sides are worked up from it. Dhurra stalks, palm leaves, and the bark of trees are used for basket making. The baskets are never painted; they vary in colour according to the kind of material used. Good and pliant mats are also made, and some of the patterns are very nice. Trays and open baskets are constructed for food, and it is protected by ornamented covers of tasteful and fanciful patterns, and invariably round.

Tanning.—As soon as animals have been skinned, the skins are scraped and then put into water in which *okun* (the bark of a tree) has been mixed. After several days they are taken out, scraped again with iron knives, and afterwards pegged out under the shade of a tree or under a shed made for the purpose; they are then rubbed and beaten with flat stones. At times they are also rubbed with butter.

Pottery.—The jars and pots constructed by the Fors are of fairly good quality. They are chiefly made by the women, and no potters' wheel is used. After the clay has been freed from stones and lumps it is beaten with heavy stones, and water is added to bring it to a proper consistence. A ball of this dough is then made, large enough to form the bottom of a jar, which is then moulded by a series of stone or solid clay-blocks being pressed into the soft clay; rings of clay are then added to form the sides of the jar and it is smoothed by the hands. Sometimes they ornament the pots; plait, cross lines, and herring bone patterns are alone used, and are formed by a sharp-pointed stick.

The pottery is burnt in a large hole dug in the ground in which the pots are placed, and which is then covered by a framework of wood strewn with earth. Over this a large fire is made and kept up for a day or two. Small images of men and cattle are made in clay as toys.

Dyeing.—I was unable to gain any information on this point, but I know that red, black, blue, and dirty green dyes are made. The black is called *dego* and is procured from the bark of a tree named *pedan*. The red is known as *pucki* from a plant called *klutu.*

Music.—The Fors are very fond of music, and have several musical instruments, which they play with more or less proficiency. They have drums of various sizes—some so large as to form a good load for a man, others of smaller calibre. Each village has a collection of drums in common, apart from those possessed by individuals. The drums, which are broader at one end than the other, are made of hard wood, hollowed out by knives. They are covered at the ends by parchment, and the two coverings are laced together by thongs, which can be tightened at will. They are played with sticks and fingers.

There are two varieties of flutes, made from reeds or hard wood. One kind is blown from the side, and has six notes, producing low tones; it is about 18 to 20 inches long. The other flute is much larger; a plug is placed at one end, leaving only a small aperture, through which the instrument is blown. The flutes are held as in Europe.

Trumpets are made from the horns of bulls, sheep, goats, and antelopes, and from elephant's tusks. Signals are sometimes given by them, but mostly by drums. There are two kinds of harps. One shaped somewhat like a lyre; the half of a large gourd is taken and two holes made in it, into which are fitted two upright sticks, which diverge a little from each other. They are united near the top by a cross bar, from which six strings made of sinews are carried down, and passed through small holes made in the gourd, on the inside of which they are fastened to small pieces of wood. The gourd is then covered by a skin. This harp is rested on the knee and played with both hands. The other one is much larger and heavier, and rests upon the ground when played on. It is constructed like a mandolin and has twelve strings, all of which are made of the sinews of animals. Another kind of musical instrument is a small bow, strung with horse-hair; one end of this bow is placed in the mouth against the teeth, and the music is produced by striking the hair with a switch. Gourds filled with small stones are used as rattles. Bells are made, the clappers of which are continuous with the handle and do not move, but the bells strike against them. I will mention one more instrument resembling our hurdy-gurdy. An elongated drum has a large number of holes bored in its side, through which pointed sticks of varying lengths are driven. A crooked stick passes through the centre of the drum, and when turned it causes the pointed sticks to vibrate, producing strains of music marvellous. The only real orchestras to be found in Darfur are those composed of flutes, rattles, and sometimes small drums, which discourse really harmonious melodies. There are no professional musicians, although they have some women who make a livelihood by singing and dancing. They attend feasts, marriages, &c. The For songs are very numerous, and are usually accompanied by music. Solo songs are sung, and songs in chorus; sometimes both are combined. The Fors can apparently pick up very readily foreign airs, and are not slow in learning to play European instruments. I often heard the Dara band perform, and although they had only been a very short time under instruction their performances were highly creditable.

Writing.—The only writing in Darfur is in the Arabic character. Few people use it, but it must have been introduced centuries ago, as all the books of For law, and those giving instruction in the preparation of drugs and charms, are written in the For language in Arabic characters. I was unable to obtain any specimen of it, much as I tried to do so. The art of drawing is unknown.

Astronomy.—The Fors' knowledge of astronomy is very rudimental. The months are lunar, but there are no ceremonies connected with seeing the new moon for the first time. The day is divided by the heights of the sun. They have names for only a very few stars.

Arithmetic.—The Fors count as far as hundreds, but have no word for a thousand. They use strings of beads for counting, as also small stones. As far as I could make out, fingers and toes are not used for the purpose. I inquired particularly about this. The Arabic notation is in vogue amongst the educated people. They are only capable of making the simplest calculations, and this is done mentally.

A Short Vocabulary of the For Language.

Antelope	Munu.
Arm	Donah.
Arrow	Korr.
Axe	Bo.
Bedstead	Pidi.
Beer	Kera.
Beads, White	Badiana.
„ Red.	Marigana.
Beard	Furu.
Bow	Napar'.
Boy	Kwatin.
Brother	Bein.
Brook	Kura Soruba.
Cat	Bis.
Calf of leg	Toringdolgoin.
Child	Kwa.
Chin	Karu or Asa.
Cloth	Guri.
Clouds	Kuttu.
Cow	Uh.
Chief	Sagal.
Crocodile	Taubareh.

Dog	Assă.
Drum	Kisu.
Ear	Dilo.
Earth	Du.
Elephant	Engri.
Eye	Nui.
Father	Babă.
Face	Kumi.
Fire	Utŏ.
Fence	Giabl.
Fish	Pun.
Fishhook	Nyamdam.
Finger	Toringa.
Flute	Morli.
Foot	Tar.
Forest	Kuruma.
Forehead	Eri Muji.
Fowl	Doga.
Gazelle	Pra.
Girl	Kwann.
Goat	Diu.
Grass	Dei.
Hand	Donahsor.
,, Palm of	Donahdiu.
Hair of head	Gabbu nilu.
Harp	Kurbe.
Heaven	Jouel.
Hell	Uddu.
Hippopotamus	Lieu.
Horse	Murta.
Hoe	Bouten.
House	Joug.
Iron	Doura.
Ivory	Engridagi.
King	Abbakuri.
Knife	Sagin.
Lake	Birga.
Leg	Tar.
Leopard	Giara.
Lion	Muru.
Man	Duo.
Millet	Kam.
Moon	Duāl.
Mother	Ama.
Mouth	Udŏ.
Monkey	Karou.
Mouse	Moui.
Moustache	Dulenge.
Mountain	Pugŏ.
Morning	Losari.
Night	Lodikoin.
Nail finger	Karu.
Nose	Dormi.
Neck	Ku-i.
Ox	Nu.
Rat	Gummul.
Rain	Kwi.
River	Bow.
Rope	Bord.
Sandal	Dowla.
Serpent	Num.
Sister	Dadă.
Shield	Kerbi.
Sun	Dule.
Star	Uri.
Sheep	Urī.
Spear	Kori.
Sword	Sarr.
Tobacco	Tabă.
Tooth	Dagi.
Thigh	Dinil.
Tongue	Dali.
Tree	Kuru.
Wood (timber)	Eir.
,, fire	Eira.
Water	Koro.
Well	Trohr.
Wheat	Karu.
Woman	Dunyan.
Bad	Tulabă.
Big	Apah.
Black	Diko.
Clean	Tay.
Dirty	Kusay.
Fat	Dai.
Good	Tulai.
Little	Itng.
No	Kei-elba.
Red	Puka.
White	Puta.
Yes	Woi.
1.	Dik.
2.	Go.
3.	Is.
4.	Ungal.
5.	Ors.
6.	Sundi.
7.	Servi.
8.	Tuman.
9.	Tisi.
10.	Wei.
11.	Weni

2. On Bisulphide of Carbon Prisms. By Dr Daniel Draper. Communicated by Professor Piazzi Smyth.

New York Meteorological Observatory,
May 27th, 1885.

C. Piazzi Smyth,
Astronomer Royal of Scotland.

Dear Sir,—I take pleasure in answering your kind note of May 9th, in regard to the experiments made by my brother Dr Henry Draper, on bisulphide of carbon prisms.

In this letter I shall only refer to those portions of my brother's experiments, which did not appear in sufficient detail in the paper published in the *American Journal of Science*, by Professor George F. Barker of the University of Pennsylvania.

My brother was led to perform these experiments with bisulphide of carbon prisms, with the stirrer, and uniform temperature bar, on account of the trouble he had experienced while working upon "Oxygen in the Sun" in his old laboratory, in getting coincidences between the solar spectrum, and the spectra of various other substances with the electric spark. He found that sometimes the lines of the overlapping spectra would coincide, and at other times there would be discrepancies, although the experiments appeared to have been made in exactly the same manner each time.

On continuing these experiments on oxygen in his new laboratory he found that the discrepancies were much greater than before. This led him to suspect that the lack of coincidence was due to temperature.

At about this time Mr Lewis M. Rutherfurd told my brother of his experience, in shaking the bisulphide of carbon prisms just before using them, and the surprising results they gave, and also the short time of their continuance to give good results.

My brother and I, in talking this subject over, decided to see if some simple plan could not be devised to keep the fluid in the prism continually stirred, or shaken by some small steady motor power. To try this device brother Henry borrowed from our brother-in-law, Dr Mytton Maury, his Edison electric pen, which consists of a very small magneto-electric engine, mounted on the upper end of a (stylus) or light tube, through which a needle point is caused to move very rapidly up and down, and having power enough to prick holes in this legal cap paper. On attaching a propeller or stirrer to it, it was found that there was sufficient power to keep the propeller in motion, and obtain the results that are mentioned in Professor Barker's paper.

To prevent the dangerous escape of the bisulphide of carbon vapour from the prism, which you justly fear, a mercurial stuffing box was employed. . . . . In the neck of the bisulphide prism bottle, a little below the upper edge, is a cork, that has through its centre a small glass tube; through this passes a steel wire or shaft having attached to its lower end the propeller, half an inch in diameter. On the upper end of the shaft is fastened a small glass cap with its opening downwards, so as to dip below the surface of the mercury, in the upper portion of the neck of the bottle above the cork. On the top of this cap is fastened a pulley to receive motion from the Edison electric motor (just described) by means of a thread or small belt. It was found that, even when the propeller was caused to revolve very fast, there was not the slightest leakage of the vapour of the bisulphide of carbon. . . . .

The controlling of the temperature inside of the prism box is accomplished by the use of two thermostat bars that were made under my direction for brother Henry. They are on the same principle as those that I invented many years ago for the taking of observations on temperature at the New York Observatory. Each bar consists of a strip of vulcanite a foot long, one inch wide, and $\frac{1}{10}$ of an inch thick, riveted to a similar strip of brass only $\frac{2}{100}$ of an inch thick. The rivets are in two rows set one inch apart. One end of the bar is fastened firmly to a block, while the other end is free to move with the changes of temperature. The vulcanite expanding more than the brass, causes the thermostat bar to bend towards the brass side, on an increase of temperature; but if it falls, the bar bends the reverse way. On the loose end of the bar is an adjusting screw (with a platinum point for electric contacts), so that it can be set for any temperature. We used two of these bars so as to have very quick action. If there is the slightest fall of temperature in the prism box, the platinum points of the bars come in contact, causing the current of the battery to pass through the electro-magnet, and open the valve of the gas lamp to give more heat in the metal pipe of the prism box. If it becomes too warm in the box, the reverse action takes place; the current is broken, and the heat is shut off.

Just before my brother's death, it was decided to make a slight change in the heating part of the apparatus, because on one occasion, as we were watching it, we found that the sudden action of the electro-magnet on the valve of the gas lamp in shutting off the heat had caused the light to become extinguished. On the cooling of the inside of the box the electro-magnet opened the valve, and allowed the gas to escape into the room, making it very dangerous. It was then decided to change this portion of the apparatus. It was thought that it would be safer to have the electro-magnet control a damper in the hot air pipe, than the lever of the gas lamp. . . . . It was also decided to have the hot air pipe in the prism box make several turns around its inside, so as to dispense with the double box and cotton filling, and have a more even distribution of heat throughout the box.

What you so kindly say of my brother's early death is too painfully true. It awakens reminiscences that cannot, and should not be forgotten. If some twenty years ago you could have looked into the laboratory at Hastings, you would have witnessed the interesting sight of my father John William Draper, and his three sons all discussing together the best plan to be followed in the building of my brother Henry's observatory, and then after its construction father would often leave his work on the *Intellectual Development of Europe*, and go to the observatory to deliberate what observations should be made, and how they should be carried on, Father was a born astronomer, scientist, and historian. When only eight years of age he attempted to make a Gregorian telescope like the one he saw his father using.

But how strange is death. Brother Henry, in the prime of life, followed father to the grave in ten short months.—I am, very truly yours,

DANIEL DRAPER.

3. Vital Relations of Micro-Organisms to Tissue Elements. By G. Sims Woodhead, M.D., and Arthur W. Hare, M.B. Communicated by Professor Turner.

In entering upon the consideration of a subject so important, one cannot but feel surprised at the very general obscurity which envelops a question upon which so large a mass of accurate detail has been collected. In looking for the cause of this unsatisfactory state of affairs, it would appear to be due to a lack of appreciation by one set of workers, of the methods pursued by another, and this in two directions. In the first place, the student of normal cell life relegates aberrant vital processes entirely to the domain of pure pathology; whilst the pathologist, relying mainly on organs as a whole for his views on function, normal and abnormal, is apt to ignore the value of the study of the cell processes as carried on under normal conditions. How without the aid of such study are we to explain inherited variability in cells? How without its aid can we interpret aright the numerous processes which, minute or almost imperceptible in the unit, in the aggregate, constitute a disease? Conversely, how is the student of cell life to make a complete analysis of normal vital phenomena if he fails to contemplate the striking analogies presented in morbid conditions? Mr Geddes, in a paper on the cell theory, read before this Society in 1883, attempted to remove this reproach on the one hand, whilst on the other there are already signs of a growing recognition among pathologists of the claims upon their attention of those fundamental vital phenomena of cells so fully expounded by Goodsir and Virchow.

For our present purposes it will be necessary to quote merely a definition of pathological changes in cells as "those variations which happen not to be conducive to success in the struggle for existence." Taking the theory that "variation and disease in the cell are closely allied," to start from, it will be curious to observe how the cycle in cell life, or parts of it, may be traced in those processes which are initiated through the action upon them of micro-organisms.

That such a "variation" theory of disease is now largely held is evidenced by the definitions quoted in our paper, as given by various modern pathologists.

These may be shortly summed up in such a phrase as "vital processes under abnormal external conditions."

In the present paper are considered those external abnormal conditions supplied by the presence of micro-organisms.

The subject must be approached from two points of view—(1) the nature and function of the altering agent, represented by the micro-organisms; and (2) the nature of the alterations and reactions set up in the elements acted upon, represented by the tissue changes.

It has now been proved experimentally that micro-organisms act upon complex nitrogenous bodies, as do several classes higher in the organic scale, *e.g.*, animals and insectivorous plants, by a process very nearly allied to true digestion. Their function from a chemical point of view, as Frankland and others have pointed out, is analytical and not synthetical, and by this difference they are at once widely separated from the majority of the more specialised members of the vegetable kingdom.

In carrying on their analytical functions the same sequence occurs as in the digestion of albuminoid matters in the animal digestive apparatus, and experiment shows that their action upon an insoluble albumen, such as fibrin, produces a soluble globulin and other bye-products identical with those evolved in tryptic digestion. Further, Pasteur has recently expressed the opinion, basing his view on numerous analogies, that perfect digestion in animals cannot take place without the presence of micro-organisms; and Duclaux states that the process of caseation in tubercle is due to, or at least advances *pari passu* with, the production of a ferment which acts upon milk in the same way as pancreatic juice or trypsin. We may consider then, that it is after the production of these ferments, and after they have exerted their digestive action upon the tissues, that micro-organisms can obtain food material in an assimilable form, which they can utilise in their growth and development.

The same soluble products of the ordinary processes of digestion are equally well adapted for the nutrition of the animal. Digestion, then, from this point of view, is a process of fermentation, in which the ferment-producers do not utilise the whole of the material on which they act, but set free a very large proportion of elaborated food material which may be applied to the use of the organisation in which the process is carrried on. It would appear that this same law governs the processes set up by micro-organisms in the tissues of their host in several of the specific infective diseases, and that the products of the fermentation set up, are applied, at least in part, to the nutritive purposes of the organisms themselves, and, in part, to prepare living or only partially devitalised tissues for further assimilative processes on the part of these micro-organisms. But beyond this, in some cases, a product is elaborated which, acting as an antiseptic, destroys the vitality of the organism which produced it.

The existence of these special products is now generally acknowledged. They are not necessarily accompanied in their distribution by the organism which produced them on account of their greater diffusibility. The organism will, however, usually be found at some point whence absorption of its products might occur. In those cases where it is not found in such a position, and where typical traces of its action may be met with, we have abundant evidence that, owing to the exhaustion of the material necessary for its nutrition, it has ceased to exist, but its progeny have migrated to, and are found in, the less altered tissues in the immediate neighbourhood, prepared for their reception by the products of the primary fermentative process.

Up to this point the paper deals with the subject of the organised irritant agent; we must next turn to the reactions brought about in the cell elements of the invaded tissues, and we shall find that these reactionary changes have a definite relation to the nature of the irritant and the conditions under which it is applied. Under normal and constant conditions we might anticipate that the cells of any part of one of the higher organisms would continue to be reproduced at a fixed rate, to perform their function and die, a regular proportion of young, functionally active and dying cells, being maintained throughout. We know, however, that such a cycle, if left alone goes on for a certain period only, and that there comes a time at which the reproduction is not equal to the removal, and that consequently organic death takes place, and the species dies out if the process is not again commenced *ab ovo.* But there are conditions in which the regular cycle is interfered with. The external conditions or moulding forces may be so altered that the reaction of the tissue to these forces manifests itself in a form which varies somewhat from that observed under normal conditions.

The constant presence of micro-organisms upon the free surfaces, and within the cavities of the body, gives rise to the question, Why are they not normally present in the tissues? Here we may adopt Lister's theory of standard vitality, based on the absence of micro-organisms from the healthy urethra and from a wound healing by first intention. Unless this standard vitality of cell elements be in some way impaired, all the conditions are unfavourable to the growth of micro-organisms. The circumstances in which we have depression of tissue vitality include, in addition to general organic depressants, such structural features as the formation of cavities, pouches, and wounds, in which there may be accumulation of secretions or other effete products, the structure, function, and arrangement of the epithelium covering a free surface, the position of the surface and its relations, first, to the external world, and second, to the deeper tissues, especially to the lymphatics, the number, size, and relation of these lymphatics, the tissues in which they occur, and the relations of the lymphatics to the small veins. Several instances might be quoted from the paper in illustration of the bearing of these several factors on the invasion of the tissues by micro-organisms. According to certain differences in the character and distribution of these invasions, it is possible to form a general classification of the action of the organisms which give rise to them.

(1) This action may be purely local, and accurately confined to one area, beyond which neither the micro-organisms nor their products have any effect. (2) There may be a purely local action in the first instance, but this localisation is only temporary. The invasion goes on in stages, point after point being attacked. The spores developed at one point are transported to others, and so the process goes on intermittently, as in actinomycosis. (3) The organism may be limited to a definite tract, but its products may be diffused throughout the whole of the invaded organisation, as in certain cases of septicæmia. (4) There is no limitation to the sphere of activity of the micro-organism, which, with its irritant products may penetrate to all parts of the tissues, and so give rise to a general disease, as in the case of the organisms which give rise to the specific fevers.

In all these cases several factors must be taken into account in considering the changes which result from the presence, during their life history, of micro-organisms in the tissues. They may act (*a*) merely as mechanical irritants, as do particles of coal or stone in coal miner's or stone mason's lung. (*b*) By the evolution of an irritant digestive product or "ptomäine," which may act generally or locally. (*c*) In the third place, it may be suggested that in certain cases there is, in addition to the preceding factors, a subtle physico-chemical or molecular reaction between the micro-organisms and the cells, which may give rise to changes, local or general, and which might be compared to the action of the sperm cell on the germ cell or ovum. It is in connection with these points, and with regard to the varied degrees in which the infective process occurs in various species of parasitic organisms, that we wish specially to speak, for recent work of numerous observers upon these questions appears capable of throwing a clearer light upon the matter than has previously been the case.

The five following types of tissue reaction may be taken as illustrative of the principal pathological processes of micro-organismal origin. (1) Septicæmia, in which there is an absorption of septic products from an external or localised internal source, but no absorption of the organisms which give rise to them. Diffusion of products. (2) Specific infective fevers. No localised source after period of incubation. General diffusion of both organisms and products. (3) Abscess formation. Micro-organisms in area strictly localised by "pyogenic membrane." Rapid death of that area. (4) Tubercle. Micro-organisms localised. Slower death and caseation of area in which they occur. Slight tendency to fibrous tissue formation. (5) Actinomycosis. Localisation of micro-organism. Little tendency to death of proliferated cells. Greater tendency to fibrous tissue formation.

Without attempting to enter fully into the description of the process involved in tissue reaction in each of the classes above named, we may briefly summarise the many features, and illustrate them by one or two examples. Amongst the chief forms in which cell activity exhibits itself during various stages of the life cycle, are, according to Mr Geddes, (1) the amœboid stage, where nutritive activity is well marked, but where formative activity is not yet distinctly manifested. (2) The plasmodial stage, where there is excessive nutrition or excessive stimulation, and where there is latent formative tendency, which comes into play on the removal of excessive stimulation. (3) The encysted stage, where the formative activity is a more prominent feature than the nutritive. In normal tissues under normal conditions, the metabolic processes balance one another. Under the influence of irritation, this balance is lost; there is first, excessive nutritive activity, corresponding to the amœboid stage, in which the process of aggregation is well marked, as instanced by cloudy swelling of the cells of various organs during the early stages of specific infective fevers. If the irritation is continued, this is followed by greatly increased nutritive activity, or rather digestive power, which is found in the plasmodial stage. In both these forms, if the irritant be excessive, complete aggregation, followed by disintegration, takes place; while, if irritation be not excessive, formative activity is evolved, and we have a tissue formation corresponding to the encysted stage of the cell. In our paper we have attempted to illustrate these processes by a description of the phenomena observed on a septic granulating surface, in an abscess, in actinomycosis, and in tubercle.

From Marshall Ward's recent researches on the mode of reproduction in certain cellular organisms, it appears that it is possible for a parasitic fungus to reproduce its like without the direct aid of a sexual process, the necessary stimulus to multiplication being supplied by the highly organised proteids, derived from the tissues of its host, which in their turn are also stimulated into proliferation. Applying this to the case of cells in an animal, it would appear that the stimulus applied by the presence of micro-organisms, or their chemical products, acts in a manner comparable to the action of the male element upon the ovum in setting up segmentation. There is thus a reappearance of excessive reproductive activity without the process being re-initiated *ab ovo.* Cell proliferation may be set up by effete products or other chemical irritants, or even by mechanical irritants, as pointed out by Charles and Francis Darwin in connection with their researches on insectivorous plants, and the results, though varying greatly in degree, are absolutely one in kind. Apply any irritant to a surface, or a tissue, and the result is a tendency to proliferation of the cells. This appears to be the case especially in

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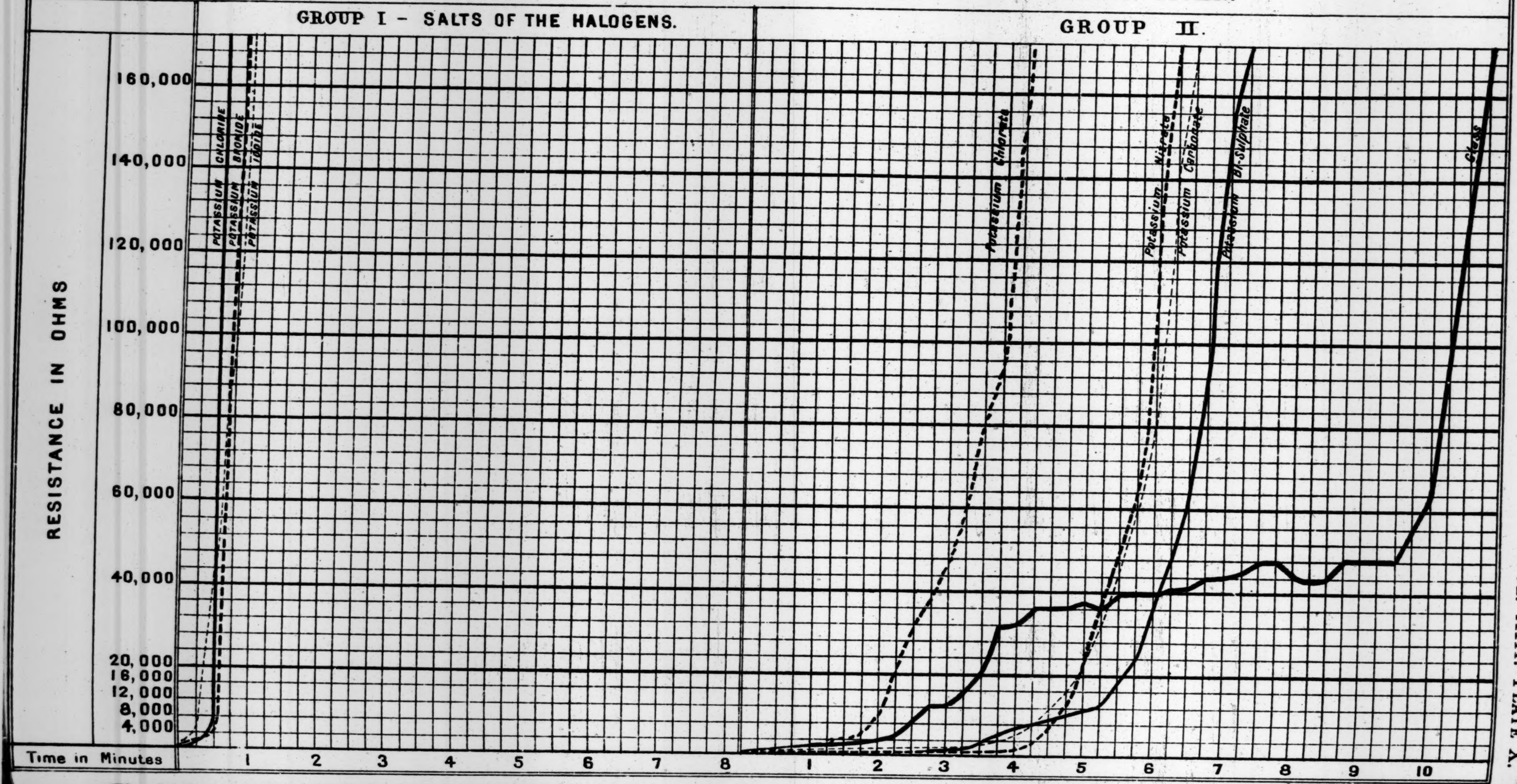
CURVES INDICATING THE TIME CHANGES OF RESISTANCE (IN OHMS) OF FUSED SALTS AND GLASS DURING RECRYSTALLIZATION ON COOLING FROM TEMPERATURES GIVEN.



The highest temperature in case of each Salt at commencement was measured by a Siemen's Pyrometer, being the average the connective tissue group, where the increase in the number of cells is extremely marked. With this increased cell formation there is apparently a taking up of the irritant material by the cells, and if one cell is not sufficient for the task a number combine to form plasmodia or giant cells. That the taking up of these products, or the micro-organisms themselves, further lowers the vitality of the cell, may be inferred from the fact that as soon as the cell becomes filled with the irritant particles it dies, and with its contained material, acts as an irritant to other cells. The chemical products then may be looked upon as the prime movers in bringing about a proliferation of the cells with which they come in contact; by this proliferation the cells appear to attempt to get rid of the irritant material by which their resisting power is greatly diminished.

Edinburgh is now thoroughly equipped for bacterological investigations, as there are complete apparatus and very complete arrangements for carrying on such investigations in several of the departments. A part of the pathological laboratory has been adapted for such work; and in the surgical department Professor Chiene has established a complete bacterological laboratory. There is a similar laboratory in the department of practice of physic. In all these laboratories useful work is at present going forward, under the guidance of the several professors, and there is every prospect that the Edinburgh School may contribute additions to the science of mycology not unworthy of her high reputation in other branches of science.

In conclusion, we desire to express our sense of indebtedness to Professors Greenfield and Chiene for suggestions and encouragement whilst carrying on in their laboratories the work upon which this paper is based.

4. The Resistance during Recrystallisation of fused Salts of the Halogens compared with some others and Glass. By Thomas Andrews, F.R.S.E., F.C.S., Wortley, near Sheffield. (Plate X.)

The electrical resistance manifested relatively by certain fused salts is peculiar. The following communication contains the result of observations on time changes of resistances noticed during the cooling and resolidification of two typical groups of fused salts and also of molten glass.

The salts (analytically pure) employed were—

Group I.—Potassium chloride, potassium iodide, potassium bromide (three salts of the halogens).

Group II.—Potassium carbonate, potassium nitrate, potassium chlorate, potassium bisulphate and glass.

The glass used in the observations was a powdered sample showing the following composition :—

Analysis of the Glass employed.

The sample, dried at 212° Fahr., gave the following results :—

Silica.	Alumina.	Peroxide of Iron.	Oxide of Manganese.	Magnesia.	Lime.	Potash and traces of Soda.	Carbonic Acid.	Total.
72·35	1·00	0·40	0·65	0·77	7·76	15·31	traces.	98·24
The sample contained no lead, copper, or barium.								

The fusions were made in a platinum crucible, using a Fletcher's Bunsen burner, either with or without blast as required. The galvanometer employed was an astatic one (the R. of which at 20° C. was 521 ohms) of known constants, and which, to ensure accuracy, was carefully calibrated during the investigation. With the salts in fusion and raised to the high temperatures given, it was found that when a Daniell's element (zinc in cold saturated solution of zinc sulphate, copper in concentrated sulphate of copper with crystals) was placed in circuit (using two platinum wires as electrodes), the resistance of the fusing salts or glass varied of course very greatly with the temperature. On allowing cooling to commence, the conductivity in the case of the salts (Group I.), almost immediately ceased, although the temperature would only be just below their fusing points. It will be seen, however, from Table A. that the current from the Daniell's continued to pass, in the case of the other salts and glass, for a considerable time.

Owing to the difficulty of obtaining a steady and gradual rise of temperature in melting the salts and powdered glass, the reverse method of taking the time change resistances during gradual cooling from the highest temperature to recrystallisation was adopted. A weighed portion (300 grains) of each salt, &c., contained in the platinum crucible was first melted and raised to the high temperature given (consistent with the nature of the substance), which was measured by a special arrangement with a Siemen's pyrometer. The ends of two strong platinum wires (0·063 inch diam.), connected with the Daniell's element, remained deeply immersed in the salt from commencement, at equal distances apart in each case ($\frac{1}{4}$ inch); the galvanometer and resistance coils were also in circuit. The resistance was then taken at the highest temperature, the source of heat instantly removed, and the fused salt or glass allowed gradually to cool. The time changes of the deflections of the galvanometer were then recorded every 15 seconds (the resistance, values, &c., of which were known from the calibration of the galvanometer), until final solidification of the salt or glass ensued, and the current from the Daniell's ceased to pass.

This method afforded an indication of the nature of the resistance of both groups of the fusing salts and glass through considerable ranges of temperature, during the varying molecular changes incident to recrystallisation on cooling.

The curves of the resistances thus obtained are given in Table A.

Remarks on Table A.

Potassium Carbonate.—This salt allowed a feeble current to pass until 8 minutes from commencement, at a comparatively low temperature.

Potassium nitrate and Potassium chlorate.—A very faint current continued to pass (through higher resistances) after the above measurements were taken, until the salts were quite cold.

Potassium chloride, Potassium iodide, and Potassium bromide.—The resistance of these fused salts was observed many times with the above results, after a very short time from the commencement of cooling in each experiment, the resistance almost instantly increased to an enormous extent, allowing only the feeblest current from the Daniell's to pass, although the salt was still at a high temperature, the KCl quite a bright red, and the KI still showing distinctly red. The property of bad conductivity during such high temperature appears peculiar to these salts. In the case of KBr, when at 845° C., there was a free passage of the current, but

TABLE A.

TIME CHANGES OF RESISTANCE OF FUSED SALTS AND GLASS DURING RECRYSTALLISATION ON COOLING FROM TEMPERATURES GIVEN.

Time from commencement of cooling.		Group I.—Salts of the Halogens.			Group II.				
		Potas. Chloride.	Potas. Iodide.	Potas. Bromide.	Potas. Carbonate.	Potas. Nitrate.	Potas. Chlorate.	Potas. Bisulphate.	Glass.
		Highest Temp. 845° C.	Highest Temp. 695° C.	Highest Temp. 699° C.	Highest Temp. 845° C.	Highest Temp. 694° C.	Highest Temp. 422° C.	Highest Temp. 400° C.	Highest Temp. 845° C.
Min.	Sec.	Resistance in Ohms.	Resistance in Ohms.	Resistance in Ohms.	Resistance in Ohms.	Resistance in Ohms.	Resistance in Ohms.	Resistance in Ohms.	Resistance in Ohms
	0	20	353	585	10	10	70	10	67
	15	123	5,390	1,141	52	80	353	52	108
	30	8,000	38,805	5,920	327	134	492	108	134
	45	...	95,574	154,830	550	160	705	160	215
1	0	...	266,948	zero	585	187	1,160	215	327
	15	...	...	...	705	201	1,930	270	550
	30	...	533,896	...	890	215	3,410	298	1,025
	45	...	...	...	1,085	270	6,200	327	2,020
2	0	...	...	...	1,230	353	10,730	406	3,850
	15	...	...	...	960	406	20,755	830	4,750
	30	...	...	...	1,160	521	31,406	1,025	8,870
	45	...	...	...	1,370	615	38,805	1,290	11,500
3	0	...	...	...	1,760	765	48,234	1,600	12,500
	15	...	...	...	2,310	925	59,136	2,210	16,506
	30	...	...	...	3,130	1,122	80,043	3,130	20,755
	45	...	...	...	4,550	1,440	95,574	4,730	31,406
4	0	...	...	...	6,200	2,020	154,830	6,800	31,406
	15	...	...	...	8,870	3,850	210,889	8,400	35,675
	30	...	...	...	12,500	7,930	266,948	9,450	35,675
	45	...	...	...	16,506	14,389	A feeble current continued till galvanometer at 8 minutes reached zero.	10,730	35,675
5	0	...	...	...	23,967	23,967		11,500	37,240
	15	...	...	...	35,675	38,805		13,428	35,675
	30	...	...	...	48,234	50,997		18,632	38,179
	45	...	...	...	59,136	64,512		23,967	38,805
6	0	...	...	...	80,043	125,202	...	38,805	38,805
	15	...	...	...	139,347	170,313	...	48,234	40,966
	30	...	...	...	170,313	170,313	...	64,512	40,966
	45	...	...	...	210,889	170,313	...	95,574	43,128
7	0	...	...	...	A feeble current continued till galvanometer at 8 minutes reached zero.	210,889	...	154,830	43,128
	15	...	...	...		210,889	...	170,313	45,681
	30	...	...	...		210,889	...	210,889	48,234
	45	...	...	...		266,948	...	210,889	48,234
8	0	...	...	...		A feeble current continued till galvanometer at 10 minutes reached zero.	...	266,948	45,681
	15	...	...	...	...		...	A feeble current continued till galvanometer at 9 min. 15 sec. reached zero.	43,128
	30	...	...	...	...		...		43,128
	45	...	...	...	...		...		48,234
9	0	...	...	...	...		...		48,234
	15	...	...	...	...	...	...		48,234
	30	...	...	...	...	...	...		48,234
	45	...	...	...	...	...	...	...	...
10	0	...	...	...	...	...	...	...	64,512
	15	...	...	...	...	...	...	...	95,574
	30	...	...	...	...	...	...	...	125,202
	45	...	...	...	...	...	...	...	154,830
11	0	...	...	...	...	...	...	...	...

on reducing the temperature to about 676° C. (the salt being apparently in a red hot semi-pasty condition), the flow of the current was almost stopped, the R. of the salt was then about 154,830 ohms. With a temperature somewhat below the last named, the salt entirely ceased to conduct.

As all the experiments in this memoir were conducted under similar conditions, the comparative results are interesting, and afford a further indication of the generally non-conducting character of these salts of the halogen group, below their fusing points (KCl fusing point 734° C., KI fusing point 634° C., KBr fusing point 699° C.), the reverse being the case with the other salts and glass employed. The author has not made any observations on the fluorides.

5. Notice of a Second Specimen of Sowerby's Whale (*Mesoplodon bidens*), from Shetland. By Professor W. Turner, M.B., LL.D., F.R.S.

The Shetland seas are frequented by several species of Ziphioid whales. Since the year 1870 I have come into possession of, and placed in the Anatomical Museum of the University of Edinburgh, the skull of *Ziphius cavirostris,*[*] the skull and a large part of the skeleton of *Hyperoodon rostratus,* and the skull and almost complete skeleton of *Mesoplodon bidens.*[†] They were all captured on the north-east side of the mainland of Shetland.

On the 2nd June of this year I was told by one of my students, Mr Charles Anderson, that a small whale had been taken a few days previously at Voxter Voe, Delting. This voe is about 13 miles from Urafirth Voe, where in April 1881 the specimen of *Mesoplodon bidens,* above referred to, had been captured by his brother, Mr Thomas Anderson of Hillswick. Mr Charles Anderson informed me that, from the description which his brother had written to him of the Voxter Voe specimen, it was also, he believed, a Sowerby's whale. I telegraphed, therefore, to Mr Thomas Inkster of Brae, near Voxter Voe, to secure the animal for me as little injured as possible. On the 15th June it arrived at the University, and proved to be a fine specimen of an adult male *Mesoplodon bidens.*

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[*] Described and figured by me in *Trans. Roy. Soc. Edin.*, May 20, 1872, vol. xxvi.

[†] Described by me to Royal Society, Edinburgh, Jan. 30, 1882. See *Proceedings* of that date, also *Jour. of Anat. and Phys.*, April 1882.

The whale had been flensed, eviscerated, and cut into blocks before being despatched to me; all the skin had been removed except that of the tail and flippers. The thoracic and abdominal viscera had been removed *en masse,* and accompanied the divided carcass. From the extent to which the animal had been cut up, my notes on the soft parts are necessarily very fragmentary; and as the specimen reached me in the hot weather in June, more than a fortnight after the death of the whale, the viscera could only be examined in a very general way.

When the various blocks were put together in their proper position, the length from the tip of the lower jaw to the mid-point of the tail was 15 feet 8 inches. The shape of the tail and flipper closely corresponded with the Ziphioid which Burmeister has named *Epiodon patachonicum* or *australe* (*Ziphius cavirostris*). The tail was dark slate grey, almost black on both surfaces. The flipper on both surfaces had the colour of a well-blackened boot. A pair of mandibular teeth projected for one inch beyond the gum, but no rudimentary denticles were seen. The blow-hole was transverse, and on the surface of the head was not divided into two nostrils. The position and form of the tongue, the relation of the larynx to the nares, and the branching of the trachea and bronchi, were examined.

The stomach was seen to consist of ten compartments, viz., a proximal cavity, which freely communicated with the œsophagus; eight globular or saccular compartments, which varied in size from a moderately sized orange to about three times that magnitude. The first saccular compartment communicated with the hinder end of the proximal cavity, and the various saccular compartments communicated in succession with each other, whilst the last one opened into the tenth compartment of the stomach.

The tenth or distal compartment was in size and shape not unlike a large human stomach; it showed an indication of a division into two parts by a projecting fold of mucous membrane which passed across it; it communicated with the duodenum. A large duct opened into the duodenum which was traced to the pancreas, and probably represented the combined pancreatic and biliary duct. The compartments of the stomach, from one to seven inclusive, contained a brownish mucus,—the eighth and ninth contained a bile-stained fluid, with a number of opaque crystalline lenses and hard white calcareous bodies, which looked not unlike the otoliths of fish. The tenth compartment contained several ounces of a bile-stained fluid, but no other contents.

The liver, heart, lungs, pelvic bones and penis, hyoid apparatus, and other bones of the skeleton were examined. A dissection was made of the extensor and flexor muscles of the flippers, and of the vessels and nerves of these limbs. [It is intended to publish a more detailed account of the visceral anatomy in the *Journal of Anatomy and Physiology*, October, 1885.]

6. Preliminary Report on the Cephalopoda collected by H.M.S. "Challenger." Part II. The Decapoda. By William E. Hoyle, M.A. (Oxon.), M.R.C.S.

It is rather remarkable that the Decapoda should have yielded fewer new forms than the Octopoda, although judging by the number of genera contained in them, the former is a much more extensive group than the latter, and is furthermore represented by a larger number in the "Challenger" collection, as the following synopsis* will show :—

Genera.	Previously known species.	New species.
Sepiola (Rondelet), Leach, .	1	...
Rossia, Owen, ...	3	...
Promachoteuthis, Hoyle, .	...	1
Sepioteuthis, Blainville, .	1	...
Loligo, Lamarck, . . .	2	5
Sepia, Linné, ...	1	10
Spirula, Lamarck, . . .	1	...
Ommastrephes, d'Orbigny, .	1	...
Todarodes, Steenstrup, . .	1	...
Bathyteuthis, Hoyle, . .	...	1
Enoploteuthis, d'Orbigny .	1	...

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* In this synopsis several forms to which Professor Steenstrup had given MS. names are reckoned as new, and a number of immature forms are not included.

Genera.	Previously known species.	New species.
Teleoteuthis, Verrill (= *Onychia*, Leseur),	1	...
Mastigoteuthis, Verrill, ...	1	...
Histiopsis, Hoyle, ...	...	1
Calliteuthis, Verrill, ...	1	...
Cranchia, Leach, ...	1	...
Taonius, Steenstrup, ...	1	1
Nautilus, Linné, ...	1	...

As usually happens the largest genera received the most additions, *e.g.*, *Sepia* and *Loligo ;* while the new genera are each represented only by a single specimen.

All the Sepias obtained by the Expedition were got between Stations 163 and 232,—that is to say, during the cruise from the eastern coast of Australia, through the Malay Archipelago to Japan ; and when this is taken in connection with the fact that of some fifty previously known species, no less than thirty come from the same area, it becomes obvious that this Indo-Pacific region is the metropolis of the genus. It is further remarkable that most of the new Loligos come from the same region.

One of the most curious of the new forms is a small creature from the Southern Ocean, which has been called *Bathyteuthis abyssicola* (fig. 2) ;* it measures about 5 cm. in length, excluding the tentacles; the body is subcylindrical, tapering to a blunt point behind, where are situated two small rounded fins. The head is broad, with prominent eyes, and there is a very large oral membrane provided with suckers. The arms are very short, the longest not quite reaching 1 cm., and the suckers are minute and arranged biserially ; the tentacles about equal the body in length, and have no clubs, but gradually taper to a point armed with numerous very small suckers like those of many *Sepiæ.* The funnel is provided with a valve, and the pen resembles that of *Ommastrephes* (see p. 308 *postea*).

The structure of this form seems to adapt it for life at great depths, and to justify the belief that it really came from the depth reached by the dredge (1600 fathoms); the small fins are in marked contrast to those of pelagic species, while the small suckers and delicate tentacles are equally little fitted for raptorial purposes; but, on the other hand, the large circumoral lip would seem well suited for collecting nutritive matters from an oozy bottom.

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* This seems to be at all events congeneric with a form which Professor Verrill has recently dredged in the North Atlantic, and named *Benthoteuthis megalops* (*Trans. Connect. Acad.*, vol. vi. part 2, page 402, pl. xliv. fig. 1).

A new genus has also been erected for the reception of another interesting Decapod, *Promachoteuthis megaptera* (*vide postea*), and a third for a specimen nearly allied to the genus *Histioteuthis*, which was obtained in the South Atlantic (Station 333); the web is very small in comparison with that of this genus, not extending quite half-way to the tips of the arms. In the present state of our knowledge it seems impossible to refer this form to any type hitherto described, and it has therefore been erected into a new genus under the name *Histiopsis atlantica*.

Among the Challenger Collection is also one mutilated individual of *Taonius hyperboreus*, Stp., a species hitherto known only from examples in the Copenhagen Museum;* there are also two medium sized specimens and a small one, which appear to be referable to the same genus. It is remarkable that many of the most interesting specimens are mere fragments; among others may be mentioned part of a tentacle of *Mastigoteuthis Agassizii*, Verrill, which was found adhering to the dredge rope, and numerous pieces of a long gelatinous pen, taken from the stomach of a shark; these latter seem to resemble nothing hitherto known so nearly as the pen of *Chiroteuthis lacertosa*, Verrill,† though, if this determination be correct, that species must sometimes attain a length of several feet.

I append definitions of the new species contained in the collection:—

MYOPSIDÆ.

PROMACHOTEUTHIS, Hoyle.

Promachoteuthis, Hoyle, Narr. Chall. Exp., vol. i. part 2, p. 270, fig. 109, 1885.

The *Body* is short, rounded, with large broad *fins*, situated posteriorly. The *mantle* is free behind, as in *Rossia*. The *siphon* is short and slender and with everted margin; valve?

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* The specimen which Verrill figures (*Trans. Connect. Acad.*, vol. v. p. 302, pl. xxvii. figs. 1, 2, 1882) is certainly not *Taonius hyperboreus*, Stp. I have elsewhere adduced arguments for believing it to be *Taonius pavo* (Les.), (*Proc. Roy. Phys. Soc. Edin.*, vol. viii. p. 319, 1885).

† *Loc. cit.*, p. 408, pl. lvi. figs. 1 *a*, *a'*, *a''*, 1881.

The *Head* is small and narrow; *eyes* not prominent.

The *Arms* are long and conical, with two series of pedunculate spherical *suckers*. The *tentacles* exactly resemble the arms at their origin; the *club* is absent?

The *Gladius* has not been removed from the single example.

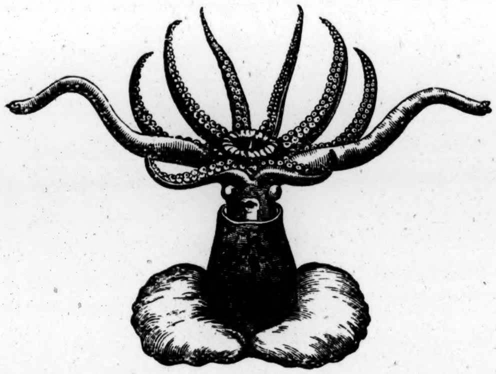

Fig. 1.—*Promachoteuthis megaptera*, Hoyle.

Promachoteuthis megaptera, Hoyle.

> *Promachoteuthis megaptera*, Hoyle, *loc. cit.;* also *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xvi. p. 182, 1885.

The *Body* is short, barrel-shaped, rounded behind; the *fin* is large, transversely elliptical, and extending beyond the end of the body posteriorly; each half is wider than long. The *mantle-margin* is transversely truncated. The *mantle-connective* consists of a linear ridge on either side, fitting into an almond-shaped depression at either side of the base of the *siphon*, which is short, slender, and has the distal margin, everted like the neck of a flask; the specimen was so small and indifferently preserved that it was not opened to ascertain whether a valve was present.

The *Head* is very small and narrow, almost the whole of its sides being occupied by the *eyes*, which are not prominent, but covered with a transparent membrane, and with a distinct pore in front of and below each.

The *Arms* are unequal, the fourth being the shortest (considerably so on the right side); the first, second, and third are subequal; they are on an average about the same length as the body, smoothly conical, and taper evenly to fine points. The *suckers* are in two series throughout, pedunculate, spherical, with a lateral aperture directed inwards; the *horny ring* is smooth and surrounded by a few large papillæ. The *hectocotylus* is not developed. There is no trace of an *umbrella*. The *buccal membrane* is well developed and has the usual seven points, but they are not very well marked nor provided with suckers; the membrane is not connected with the arms by ligaments. There seems to be only one *lip*, which is thick and papillate.

The *Tentacles* arise directly between the third and fourth arms, exactly resembling them at their origin, and obviously being part of one series with them; the *stem* is swollen at first and somewhat more than one-third up the arms narrows rather suddenly to about half its previous diameter. The *club* is wanting.

The *Surface* is smooth.

The *Colour* is a dull purplish madder, paler on the fins (especially their under surface) and on the arms and tentacles.

The *Gladius* has not been extracted.

Hab. North Pacific, east of Japan (Station 237), 1875 fathoms. One specimen, sex ?

LOLIGO, Lamarck.

Loligo ellipsura, Hoyle.

Loligo ellipsura, Hoyle, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xvi. p. 182, 1885.

The *Body* is elongated, widest anteriorly, and tapering gradually to an acute point behind. The *fin* is comparatively short, only one third the length of the body, elliptical, slightly broader than long. The *mantle-margin* passes almost straight across the back, except where a long narrow median process juts out over the head; it is slightly sinuate ventrally. The *siphon* is short and blunt.

The *Head* is short and very nearly as broad as the body; it has the usual auricular crest and preocular pore.

The *Arms* are unequal, the order of length being 3, 4, 2, 1, and about one-third the length of the body; the first has a distinct web on its dorso-median angle, and the third a still broader web on its outer aspect, passing back nearly as far as the eye, where it becomes connected with another passing up the dorso-lateral aspect of the fourth. The *suckers* are in two series, pedunculate, oblique, notched distally, and somewhat larger on the lateral than on the other arms. The *horny rings* bear from five to seven large pointed teeth in their distal portion, but are smooth proximally. The *hectocotylus* is not present. The *buccal membrane* has the usual seven points, each of which carries two or three small suckers. The *outer lip* is thick and marked with radial grooves; the *inner* was not seen.

The *Tentacle* is slender, approximately cylindrical, and about two-thirds the length of the body; its terminal fourth is occupied by the *club*, which is but little expanded, and has a delicate protective membrane along either side of the inner surface and a well-marked web externally. The large median *suckers* are about ten in number, and about twice as large as the alternating lateral; the proximal are about twenty, and gradually increasing; the distal occupy nearly one half the club, and are in four series diminishing. The *horny rings* of the largest suckers have about twenty-four distant square pointed teeth, much longer on the distal margin; the lateral ones have about half as many similar teeth on the outer margin, and the terminal suckers are armed in the same way.

The *Surface* has been almost entirely denuded of skin.

The *Colour* appears to have been pale buff with purple chromatophores.

The *Gladius* has not been extracted.

Hab. Off Sandy Point, South America (Station 313), 55 fathoms. One specimen, apparently ♀.

Loligo galatheæ, Steenstrup, MS.

Loligo galatheæ, Steenstrup, MS.
,, ,, Hoyle, *Ann. and Mag. Nat. Hist.*, ser. 5 vol. xvi. p. 183, 1885.

The *Body* is about three times as long as broad, cylindrical anteriorly, and pointed behind. The *fin* is rather less than half the length of the body,* about as long as broad, and with rounded lateral angles. The *mantle-margin* curves out rapidly to a triangular process in the dorsal median line, for the rest is almost transverse, except where it forms two obtuse angled processes, one at either side of the ventral emargination.

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* With respect to this and one or two other points in the description it must be remembered that the specimens are immature.

The *Head* is comparatively broad and with prominent rounded *eyes.* The *siphon* is moderately large and of the usual form.

The *Arms* are unequal, the order of length being 3, 4, 2, 1, and not quite one third as long as the body. The dorsal have a distinct keel on the upper margin, the second are keeled on the ventro-lateral aspect, the third are stout and flattened and have a broad web on the outer aspect, which unites with the web running up the dorso-lateral aspect of the ventral arms. The *suckers* are in two series throughout, with short peduncles, and not very oblique; their horny rings bear nearly twenty distant blunt teeth. The *hectocotylus* is not developed. The *umbrella* is absent. The *buccal membrane* has the usual seven points, each of which bears a few suckers. The *outer lip* is thin, the *inner* thin and papillate.

The *Tentacles* are comparatively short, being not quite so long as the body; the *stems* are subtriangular. The *club* occupies more than one-third of the length, and has a protective membrane at either side of the suckers and a distinct web on the outer aspect. The large central *suckers* are eight to ten in number, and nearly twice the diameter of the lateral ones; the proximal group consists of about ten, while the distal portion bears four series of diminishing suckers. The *horny ring* bears long, distant, bluntly pointed teeth, about twenty-four in the largest suckers, proportionally fewer in the smaller, which are much larger in the distal and external portions of the ring respectively.

The *Surface* is smooth.

The *Colour* is pale yellowish, spotted with brownish-purple and red chromatophores.

The *Gladius* has not been removed.

Hab. Philippine Islands (Station 203), 20 fathoms. Two specimens, juv.

Loligo kobiensis, Hoyle.

Loligo kobiensis, Hoyle, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xvi. p. 184, 1885.

The *Body* is elongated, cylindrical in the anterior moiety, then tapering posteriorly, and terminating in a blunt point. The *fin* is more than half the length of the body, trapezoidal, with rounded lateral angles; the extreme breadth is less than the length and is situated anteriorly to the middle of the fin. The *mantle-margin* presents a triangular process in the mid-dorsal line and is deeply sinuate ventrally. The *siphon* is short and bluntly conical.

The *Head* is short and not so broad as the body; the *eyes* are comparatively small and have a bracket-shaped auricular crest behind and a minute pore in front of them.

The *Arms* are unequal, the order of length being 3, 4, 2, 1, and, on the average, rather more than one-third the length of the body; the first are the most slender, and have the dorso-median angle raised into a prominent keel; the second have only a faintly-marked angle ventro-laterally; the third have a broad web externally, passing over at the base into one which extends up the dorsal aspect of the ventral arms. The *suckers* are arranged in two series, pedunculate, very oblique, and rather larger on the lateral than on the other arms; the *horny ring* has about nine short, close-set, square-cut teeth on its distal side, and is smooth on the proximal. The *hectocotylus* was not observed. The *buccal membrane* has five points, each of which bears two or three small suckers, the two ventral points are rounded off; just within the ventral margin is a small papilla surrounded by two elevated rings, probably for the reception of spermatophores. Both the *outer* and *inner lips* are folded.

The *Tentacle* is faintly three-sided and shorter than the body, one-third of its length being taken up by the *club*, which is expanded and triangular in section; there is a protective membrane on either side and a web externally; in the centre are eight large *suckers*, three times the diameter of the lateral ones; at the proximal end are about nine suckers, gradually increasing in size, and at the distal end more than twenty rows arranged in four series, gradually diminishing. The largest suckers are scarcely at all oblique, and have the margin cut up by radial grooves into a number of small papillæ, an arrangement also found on the outer margin of the lateral suckers, but not in the terminal ones. The *horny rings* of the largest suckers are smooth; those of the lateral bear about twelve long distant teeth on their outer margin; those of the terminal suckers are similarly armed.

The *Surface* is smooth.

The *Colour* is pinkish yellow, with purplish chromatophores.

The *Gladius* has not been extracted.

Hab. Off Kobi, Japan, 8 fathoms; one specimen, ♀ South of Japan (Station 233c), 11 fathoms; two specimens, juv. Also (?) Inland Sea, Japan; two specimens, juv.

Loligo edulis, Hoyle.

Loligo edulis, Hoyle, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xvi. p. 186, 1885.

The *Body* is moderately stout, being about three times as long as broad, cylindrical in its anterior third, and tapering gradually to a bluntish point. The *fin* occupies a little more than half the length of the body, is rhomboidal, not quite so broad as long, and broadest anteriorly to the middle; the lateral angles are rounded. The *mantle-margin* has a slight projection in the median dorsal line and a broad shallow sinuate excavation ventrally. The *siphon* is of moderate length and bluntly pointed.

The *Head* is small, with prominent rounded *eyes*, and bears the usual auricular crest and preocular pore.

The *Arms* are unequal, the order of length being 3, 4, 2, 1, and about half as long as the body. The first are very slender and bear a distinct keel on the dorsal aspect; the second are thicker and triangular, and have a broad keel almost expanding into a web on the lateral aspect; the third are the stoutest, flattened from above downwards, and distinctly keeled externally; the fourth are intermediate between the third and second, triangular, and with a broadish web extending the whole way up the dorso-lateral aspect. They all have a web up each side of the inner face. The *suckers* are in two series, very oblique, and with slender conical peduncles, their size varying with that of the arms on which they are situated; the *horny ring* bears eight long square-cut teeth on its distal margin. The *hectocotylus* is developed as usual on the left ventral arm, which bears proximally ten rows of suckers, then a minute sucker with an exaggerated peduncle, and beyond this two series of long conical papillæ. The *buccal membrane* has the usual seven angles produced into long lappets, each of which bears about eight suckers in two rows; the *outer lip* is moderately thick, the *inner* much thicker and marked with deep radial grooves.

The *Tentacles* are about as long as the body, with flattened *stems;* about one-third their length is occupied by the *club*, which is only slightly expanded, has a protective membrane on either side, but a dorsal web is present only at the extremity. The central *suckers* are about sixteen in number and about one-third larger than the laterals; the proximal are about ten, the distal are closely packed in four series. The *horny rings* of the largest are provided with about twenty larger teeth, with which smaller ones alternate somewhat regularly; the lateral bear about ten distant acute teeth on the outer margin, while the proximal and distal groups are similarly armed on the distal margin.

The *Surface* is smooth.

The *Colour* is a dull yellow with purplish chromatophores.

The *Gladius* is of the usual form, the narrow anterior portion being less than one-fourth of the total length.

Hab. Japan; purchased in the market, Yokohama. One specimen, ♂.

Loligo japonica, Steenstrup, MS.

Loligo japonica, Steenstrup, MS.
,, ,, Hoyle, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xvi. p. 187, 1885.

The *Body* is only moderately elongated, being about three times as long as broad, and bluntly pointed behind. The *fin* is a little more than half the length of the body, about as long as broad, rhomboidal, rounded laterally, and very slightly notched at the anterior angles. The *mantle-margin* curves gradually forward to a projecting point in the dorsal median line, and is deeply emarginate ventrally. The *siphon* is short and of the usual form.

The *Head* is comparatively large and rounded; the *eyes* are swollen and prominent.

The *Arms* are unequal, the order of length being 3, 4, 2, 1, and on an average about half as long as the body; the first are very small, slender, and rounded; the second have a prominent ventro-lateral angle, not amounting to a keel; the third have a distinct web on the outer aspect of the distal portion, which is continued backwards as a faint ridge which joins the web lying along the dorso-lateral edge of the fourth. The *suckers* are in two series, and vary in size in accordance with the arms on which they are situated; they are subglobular and oblique. The *horny ring* bears about ten broad, close-set, square-cut teeth. The *hectocotylus* is present on the left ventral arm; the distal suckers of the ventral series only are modified into conical papillæ, some of which bear a minute sucker at their tips.* The *umbrella* is absent; the *buccal membrane* is well developed, has the usual seven points, each of which bears a few small suckers (occasionally only one). The *outer lip* is thick, thicker than the *inner;* both are cut up into papillæ along the edge.

The *Tentacles* are as long as the head and body together, and have very slender, almost cylindrical *stems;* the *club* occupies about one fourth of the whole length, and is but slightly expanded. The large central *suckers* are about eight in number and fully twice the diameter of the lateral ones; proximally to them are about half a dozen suckers of different sizes, and beyond them a large number of diminishing ones arranged in four series and occupying nearly half the length of the club. The *horny ring* in the largest suckers bears about twenty-five square teeth; in the lateral suckers it bears more than twenty close-set acutely-pointed teeth, and in the distal ones about the same number of similar character.

The *Surface* is smooth.

The *Colour* is pale, with purplish chromatophores.

The *Gladius* is of quite typical form, expanded behind, and about six times as long as broad; the narrow anterior extremity occupies less than one-third the total length.

Hab. Japan; purchased in the market at Yokohama. One specimen, ♀.

SEPIA, Linné.

Sepia esculenta, Hoyle.

Sepia esculenta, Hoyle, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xvi. p. 188, 1885.

The *Body* is broad, stout, and semielliptical posteriorly. The *fins* are about one fourth of the body in breadth and commence within 6 millim. of the anterior margin, and end within 5 millim. of each other; the *mantle-margin* is produced far over the head dorsally, and evenly truncated below. The *siphon* just reaches the gap between the ventral arms.

The *Head* is broad and the *eyes* laterally prominent.

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* The description of the hectocotylus is taken from a specimen in the Copenhagen Museum.

The *Arms* are subequal, the order of length being 4, 1, 2, 3, and nearly half as long as the body; they are all more or less compressed, especially the ventral ones; they have a distinct web along the outer margin, and a rather broad membrane runs up either side of the sucker-bearing face. The *suckers* are in four series throughout, not very obliquely set; they are large and spheroidal, and have meridional markings on the outer surface; the *horny ring* is smooth and surrounded by a narrow papillate area. In the *hectocotylized* arm of the male the first four rows of suckers are normal, then come two rows of gradually diminishing suckers, succeeded by four rows of minute ones, after which they again regain their normal dimensions. The *umbrella* is narrow, widest between the second and third arms, where it reaches up to the fifth row of suckers The *buccal membrane* has the usual seven points in the male; in the female the two ventral are rounded off; the *spermatic cushion* is exceedingly well developed, and has four deep transverse grooves. The *outer lip* is thin and longitudinally corrugated; the *inner* is thick and bears numerous very long papillæ.

The *Tentacles* are absent.

The *Surface* is smooth throughout.

The *Colour* is dull grey, mottled with black above, yellowish below.

The *Shell* is elliptical in *outline*, somewhat broader behind (especially in the female); the *chitinous margin* is narrow and does not form a complete ridge across the shell below the spine; it forms two slightly expanded wings behind, and extends but a little distance over the *dorsal surface*, which is marked with coarse rugosities disposed in curved lines parallel to the anterior margin; a distinct but low rib runs down the centre. The *ventral surface* is elevated on either side of a deep median groove; the *last loculus* covers about one-fifth of the surface, and is bounded posteriorly by two slightly wavy lines, meeting at an acute angle; the *striated area* is long, and the angle between the striæ widens posteriorly. The *inner cone* is very well developed; the *limbs* arise one-fifth the length of the shell forward, and gradually become more elevated until they enclose a deep conical cavity. The *spine* is strong, pointed, and somewhat curved laterally in the female example.

Hab. Japan; purchased in the market at Yokohama. Two specimens, 1 ♂, 1 ♀

Sepia elliptica, Hoyle.

Sepia elliptica, Hoyle, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xvi. p. 189, 1885.

The *Body* is ovoid, broadest one-third from the anterior margin, pointed behind. The *fins* are one-third the width of the body, broadest in the middle, extending the whole length of the body, and approaching within 2 millim. of each other posteriorly. The *mantle-margin* not very prominent over the head dorsally. The *mantle-connective* is rather short and deep, but otherwise normal. The *siphon* is conical, reaching within 1 millim. of or quite up to the space between the ventral arms.

The *Head* is very short and broad, the *eyes* prominent.

The *Arms* are subequal, the order of length being 4, 3, 2, 1; they are nearly half the length of the body, and taper evenly to fine points; there is a distinct but narrow ridge along the fourth and a delicate web along each side of the oral aspect of the arms. The *suckers* are in four series throughout, and of moderate size, marked with inconstant meridional grooves, and there is a large notch proximally and distally in the rim. The *horny ring* has for the most part no distinct teeth, but is marked in the distal half with shallow irregular notches, which are occasionally more regular. A papillary area surrounds the horny ring. The *hectocotylus* is developed in about the middle third of the left ventral arm; beyond the eighth row of suckers the two ventral series are continued of the normal size, but the two dorsal are each represented by five minute suckers, gradually diminishing to the middle one and then increasing again; beyond this the arm exhibits no peculiarities. The *umbrella* is widest between the two lateral arms, where it extends as far as the sixth row of suckers. The *buccal membrane* bears the usual seven distinct points in the male, whilst in the female the ventral pair are lost in the thick swollen *spermatic cushion;* this is subdivided by four or five deep grooves into as many transverse ridges. The *outer lip* is thin; the *inner* bears about half a dozen rows of distinct hemispheroidal papillæ.

The *Tentacles* are about as long as the mantle; the *stem* is indistinctly three-sided; the *club* is long and wide, and bears eight series of minute equal suckers; there is a *protective membrane* on either side and a broad *fin* on the dorso-internal aspect. The *horny ring* is small and has a smooth margin.

The *Surface* is smooth.

The *Colour* is a dull grey dorsally, pale yellowish below.

The *Shell* is broad, subelliptical in *outline*, the anterior extremity bounded by two straight lines, which form obtuse rounded-off angles with each other and the sides of the shell; the posterior is rounded gradually off. The *dorsal surface* has a faint ridge passing to each of the three angles just mentioned, and is covered with curved rows of tubercles parallel to the anterior margin. The *ventral surface* is but little elevated; the *last loculus* occupies one-third of it, and is bounded behind by a broadly open curve with three or four irregular sinuations in it. The *striated area* is hollowed posteriorly, and is marked by grooves corresponding to the sinuations just mentioned. The *inner cone* arises about half-way along the striated area, curves evenly outwards, and then rises into a distinct ridge, forming a wall separate from the margin of the shell; its ventral surface is marked by a number of striæ pointing in the direction of the *spine*, which is of medium length and strength, and curved gently upwards.

Hab. South of Papua (Station 188), 28 fathoms; four specimens, 1 ♂, 3 ♀. Also Station 190, 49 fathoms; four specimens, 1 ♂, 3 ♀.

Sepia Smithi,* Hoyle.

Sepia Smithi, Hoyle, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xvi. p. 190, 1885.

The *Body* is of medium breadth, widest one-third back, curving evenly to a pointed posterior extremity. The *fin* is nearly one-third the breadth of the body, extending from the anterior margin of the mantle to within four millim. of its fellow at the posterior extremity. The *mantle-margin* projects to a considerable extent over the head dorsally, and is slightly emarginate ventrally. The *siphon* is long, reaching up to the interspace between the ventral arms.

The *Head* is of medium breadth and the *eyes* prominent.

The *Arms* are subequal, their order of length being 4, 3, 2, 1; they are a little more than half as long as the body; the dorsal are the smallest and subconical, the ventral wide and with a narrow web on the outer aspect; they all taper gradually to fine points. The *suckers* are in four series throughout, pedunculate, oblique, and notched proximally and distally, and with meridional grooves on the margin; the *horny ring* has about twenty blunt triangular teeth on the distal semicircumference, and is surrounded by a broad papillate area. The *hectocotylus* is not present. The *umbrella* is but slightly developed, reaching in its greatest extent (between the third and fourth arms) only to the fourth row of suckers. The *buccal membrane* has the usual seven points, but there is no *spermatic cushion.* The *outer lip* is moderately thick and longitudinally ribbed; the *inner* is provided with many rows of elevated rounded papillæ.

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* Called after Mr Edgar A. Smith, F.Z.S., of the British Museum.

The *Tentacles* are about as long as the mantle, and have stout three-sided *stems;* the *club* occupies about one-fourth of the whole length, and extends fully half round the stem; a protective membrane is found at either side of the suckers and a web along the dorso-median aspect of the club. The *suckers* are very numerous, minute and closely packed; the *horny ring* has about eight or ten stout distant teeth on the distal margin.

The *Surface* is for the most part smooth, but there are about five elongated elevations down each side of the body near the origin of the fin, and a few minute papillæ on the dorsal surface.

The *Colour* is a dull purplish grey above, pale ochre below.

The *Shell* is roughly elliptical in *outline;* the anterior extremity is bounded by two straight lines forming a blunt rounded angle; the sides curve evenly outwards (the greatest breadth being a little anterior to the middle) and form a bluntish point behind. The *chitinous margin* is narrow and vanishes in the median ventral line behind. The *dorsal surface* is rough, with granules arranged in rows parallel to the anterior margin; three slightly elevated tracts diverge from the spine to the three anterior angles. The *ventral surface* is little elevated; the *last loculus* occupies one fourth of the length, and is emarginate, being bounded behind by a more or less evenly curved line; the *striated area* is excavated, so that the whole shell is thin; the *inner cone* is well developed, with a thickened rounded margin, and encloses a deep pit; the limbs extend half-way along the striated area. The *spine* is long, tapering, and curves gently upwards.

Hab. South of Papua (Station 188), 28 fathoms. Four specimens, ♀.

Sepia sulcata, Hoyle.

Sepia sulcata, Hoyle, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xvi. p. 192, 1885.

The *Body* is cylindrical in its anterior fourth, then tapering gradually backwards, and pointed behind. The *fins* are one-fifth the breadth of the body, commence 2 millim. from the anterior margin of the mantle, and approach within 5 millim. of each other posteriorly; the *mantle-margin* reaches far over the head dorsally, and is evenly truncated below. The *siphon* does not extend up to the interbrachial space.

The *Head* is broad and the *eyes* very prominent; in the only specimen it is much retracted into the mantle.

The *Arms* are subequal, the order of length being 4, 3, 2, 1; they are one-third the length of the mantle, and taper gradually to slender points; the first are thin and rounded, the fourth flattened, each has a distinct ridge on the outer side, which in the fourth expands to a broad membrane. The *suckers* are in two series in the first and second arms, but with a tendency to form four series in the others, more especially in the distal portions; they are pedunculate and very oblique, and the margin is marked with meridional grooves and has a deep distal notch; the *horny ring* is small, smooth, and surrounded by a papillate area. The *hectocotylus* is present along three-fourths of the left ventral arm in the form of a groove with convex bottom, bounded on either side by a narrow fillet; on either margin of the groove is a row of minute suckers, which are larger and more distinct, and even form two series on the ventral aspect; the tip of the arm bears two series of small suckers. The *umbrella* is better developed than usual, its greatest extent (between the lateral arms) being up to the eighth row of suckers. The *buccal membrane* has the usual seven points, but not very strongly marked; the *outer lip* is smooth and thin, the *inner* papillate.

The *Tentacle* is as long as the head and body together, with a slender and somewhat flattened stem; the *club* is short and rather broad, and has a protective membrane on either side of the suckers, and a broad web on the dorsal aspect, extending for a distance equal to half its length down the stem; there are from six to eight rows of very minute *suckers*, subequal, and with smooth *horny rings*.

The *Surface* is smooth, except that on one side of the ventral surface are three slightly raised linear ridges, apparently due to contraction, and a few minute papillæ on the dorsal surface posteriorly.

The *Colour* is, on the whole, pale yellowish below, purplish above.

The *Shell* is hemielliptical in *outline* anteriorly, tapering to a point behind. The *chitinous margin* is rather broad, widest about two-thirds back; it covers all except the median third of the *dorsal surface*, which is finely rugose where free, and has a slightly elevated median portion and a faint linear ridge in the middle line posteriorly, about 3 millim. long, and terminating 2 millim. from the base of the spine. The *ventral surface* is but little elevated; the *last loculus* occupies more than one-third of it, and its posterior boundary is almost semicircular, inflected in the centre. The *inner cone* is evanescent; its limbs are chitinous and form a ventral margin to the terminal cone. A *spine* is present, but, as it had been broken off, its length and form cannot be determined.

Hab. Off the Ki Islands (Station 192), 140 fathoms. One specimen, ♂.

Sepia andreanoides, Hoyle.

Sepia andreanoides, Hoyle, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xvi, p. 193, 1885.

The *Body* is very long, broadest one-third of the way back, pointed and acuminate behind. The fins are narrow, commence 3 millim. behind the anterior margin, and terminate 5 millim. from the posterior end of the body, and, each approaching within 3 millim. of its fellow, end slightly on the dorsal aspect of the body. The *mantle-margin* extends well over the head dorsally, and is very slightly emarginate ventrally. The *siphon* extends rather further forward than the middle of the eyes, but not up to the space between the ventral arms.

The *Head* is decidedly narrower than the body and somewhat elongated; the *eyes* being distended and laterally prominent.

The *Arms* are subequal, the order of length being 1, 2, 3, 4, or 1, 4, 3, 2; they are two-fifths the length of the body, elongated, conical (except the fourth pair, which are flattened), and taper to very slender tips. The *suckers* seem to be normally in four series, but in some cases the arms are so compressed that they seem to be in only two, especially at the proximal extremities of the first and second arms; they are globular, slightly oblique, with a small aperture and smooth *horny ring.* The *hectocotylus* occupies the distal half of the left ventral arm; the suckers are normal up to the twelfth row, after which the arm widens and has a median groove from which about twelve shallow grooves pass outwards on either side, separating raised portions, each of which bears a minute sucker on the dorsal side of the groove. The *umbrella* is present only between the second and third and third and fourth arms up to the fourth row of suckers. The *buccal membrane* is well developed and has the usual seven points; in the female there is a deeply grooved *spermatic cushion.* The *outer lip* is thin and smooth, the *inner* thick and papillate.

The *Tentacles* are somewhat longer than the head and body, very slender and somewhat flattened. The *club* is flattened and expanded; along its outer margin is a very narrow membrane, and along the median edge, at some distance from the cupules, is a broad web, marked on the dorsal aspect with fine parallel shallow oblique grooves; along one margin it bears three or four series of small pedunculated *suckers,* whose *horny rings* bear very numerous and acute teeth.

The *Surface* is smooth.

The *Colour* is a dull purplish grey above, ochre with purple chromatophores below.

The *Shell* has a narrow elongated oval *outline,* somewhat pointed in front and tapering gradually backwards; the *chitinous margin* extends about one-third across the *dorsal surface,* which shows the boundary lines of the loculi clearly as brown striæ, and is very minutely roughened; the *ventral surface* is elevated, so that the shell is thick in proportion to its breadth, a narrow groove runs down the centre; the *last loculus* occupies one-fourth of the surface, and is bounded posteriorly by a shallow open curve. The *posterior extremity* is a very flattened irregular cone, to the apex of which the spine is attached; the *inner cone* is very shallow and its opening is some 4 millim. from the margin or the outer cone. The *spine* is long, straight, and points directly backward.

Hab. Japan; purchased in the market at Yokohama. Three specimens, 1 ♂, 2 ♀.

Sepia kiensis, Hoyle.

Sepia kiensis, Hoyle, *Ann. and Mag. Nat. Hist.* ser. 5, vol. xvi. p. 194, 1885.

The *Body* is narrow, widest anteriorly, and tapering gradually backwards: the *fin* is narrow, less than one quarter the breadth of the body, widening a little behind; it commences 1 millim. from the anterior margin and extends to within 2 millim. of its fellow behind. The *mantle-margin* is prominent dorsally and slightly emarginate ventrally. The *siphon* does not quite extend to the bases of the arms.

The *Head* is broad, and the *eyes* rounded and prominent.

The *Arms* are subequal, the order of length being 4, 3, 2, 1; they are very short, about one-third the length of the body; the first and second are conical, the third flatter, with a slight ridge externally, and the fourth broad and flat with a distinct crest. The *suckers* are in four series throughout, small, spheroidal, and not very oblique; the *horny ring* is smooth. The *hectocotylus* is not developed. The *umbrella* is evanescent, extending at most only up to the second row of suckers: the *buccal membrane* has five points and is rounded dorsally; the *spermatic cushion* is but slightly developed. The *outer lip* is thin and grooved longitudinally, the *inner* thicker and papillate.

The *Tentacle* is as long as the head and body; the *stem* being slender and indistinctly three-sided. The *club* is very slightly expanded; a protective membrane, grooved obliquely on the dorsal aspect, is situated on the outer margin, and there is a web on the internal side. The *suckers* are in four or five series, which are slightly larger towards the inner margin; the *horny ring* presents a few acute teeth.

The *Surface* is smooth throughout.

The *Colour* is a dull reddish grey above, yellowish below.

The *Shell* is a very elongate oval in *outline;* the *chitinous margin* is very narrow and extends only slightly over the *dorsal surface*, which is finely granular and marked by the divisions between the loculi: the *ventral surface* is somewhat elevated and marked by a distinct but not very deep median groove; the *last loculus* extends over more than one-third the shell, and is bounded posteriorly by an almost semicircular line; the *striæ* are very close; the limbs of the *inner cone* arise about midway along the shell, pass backwards as low, narrow, smooth fillets, and unite behind without forming any deep cavity; the *posterior extremity* is curved towards the ventral aspect and ends in a narrow blunt cone, to the apex of which is attached the straight somewhat dorsally directed spine.

Hab. Off the Ki Islands, south of New Guinea (Station 192), 140 fathoms. One specimen, ♀.

Sepia kobiensis, Hoyle.

Sepia kobiensis, Hoyle, *Ann. and Mag. Nat. Hist.* ser. 5, vol. xvi. p. 195, 1885.

The *Body* is long and narrow, widest near the anterior margin, and tapers gradually backwards. The *fin* is very narrow, only one-eighth of the body; it commences 3 millim. from the margin of the body, and posteriorly passes on to the ventral surface and terminates 2 millim. from its fellow and 4 millim. from the extremity of the body. The *mantle-margin* has a narrow projection over the head, and is evenly truncated ventrally. The *siphon* is short, not reaching half-way to the space between the ventral arms.

The *Head* is of medium breadth, and the *eyes* prominent laterally.

The *Arms* are subequal, the order of length being 2, 4, 3, 1, and less than one-third the length of the body; the first two pairs are subconical and slender, the third broader and with a web running up the ventral aspect, the fourth wider and with a distinct ridge along the outer edge; they all taper to very fine points. Many of the *suckers* are deficient, but they seem to have stood in four series throughout; they are spheroidal and very oblique, the distal margin of many has a deep notch: the *horny ring* is smooth in most cases, but occasionally possesses a few angular teeth. The *hectocotylus* is not developed. The *umbrella* is but little developed, its greatest extent being on the ventro-lateral aspect, where it reaches the fourth row of suckers. The *buccal membrane* has the usual seven points, the two ventral being the least distinct (as usual in female specimens); the *spermatic cushion* is small. The *outer lip* is narrow, the *inner* thick and papillate.

The *Tentacle* is shorter than the body and slender; the *stem* has three sides, the inner being slightly hollow, with a slender fillet along the middle. The *club* is slightly expanded with a distinct protective membrane; the inner side of the club is deeply grooved, and internally to the groove is a rather broad fin. The *suckers* are in about five series, near the inner margin are three rather larger than the rest, which gradually diminish towards the outer margin. The *horny rings* of the larger suckers have about twenty fine teeth on the distal semicircumference, the smaller have fewer in proportion.

The *Surface* is smooth all over.

The *Colour* is a dark purplish grey above, paler below.

The *Shell* is a very elongated oval in outline; the *chitinous margin* is very narrow and extends one-third over the *dorsal surface*, which is smooth and evenly convex, with the exception of a slight ridge along the middle line: the *ventral surface* is elevated, so that the shell is thick, with a shallow median groove becoming evanescent posteriorly, the *last loculus* occupies one-third of the surface, and is bounded by a slightly curved line with a cusp where the median groove meets it: the *inner cone* is formed by two limbs, which arise half-way along the shell and form a rounded fillet slightly more elevated posteriorly, where they bound a shallow depression: outside them the margin of the shell expands into a subcircular plate, from the centre of which the *spine* projects backwards; no information can be given as to its form or length, as it has been broken off close to the base.

Hab. Kobi, Japan, 8 fathoms. One specimen, ♀.

Sepia papuensis, Hoyle.

Sepia papuensis, Hoyle, *Ann. and Mag. Nat. Hist.* ser. 5, vol. xvi. p. 197, 1885.

The *Body* is elongated, broadest about one-third back, pointed behind: the *fins* extend the whole length of the body and are one-third of its breadth, a little wider behind; they extend to within 1 millim. of the anterior margin, but are separated by about 5 millim. posteriorly: the *mantle-margin* projects far over the head dorsally, and is slightly emarginate ventrally. The *siphon* is conical, reaching two-thirds up to the gap between the ventral arms.

The *Head* is short and broad; the *eyes* prominent.

The *Arms* are subequal, their order of length being 4, 3, 1, 2; they are about one-fourth as long as the body and taper to fine points: the dorsal are conical with a very slight ridge up the outer aspect, the third pair have a similar ridge; the ventral are flattened and bear a distinct crest. The *suckers* are in four series throughout and of moderate size, set obliquely on short peduncles, with meridional grooves on the outside: the *horny ring* bears twenty to twenty-five long, square-cut, irregular teeth in its distal semicircumference, and outside it is an area covered with close-set papillæ. The *hectocotylus* is not developed. The *umbrella* is slight, reaching only as high as the sixth row of suckers between the third and fourth arms, where it is widest; as usual it is entirely absent between the two ventral arms. The *buccal membrane* has the usual seven points. The *spermatic cushion* is not developed· the *outer lip* is smooth, except for a few ridges due to contraction; the *inner* bears numerous small papillæ.

The *Tentacles* are about as long as the body, the *stem* being three-sided: the *club* is short, flattened, and expanded, with a protective membrane on either side and a broad web down the back, reaching along the stem for a distance equal to half the length of the club; it bears six larger *suckers* in the central line, a series of smaller ones on either side, and some very minute ones along each margin: at the top are fifteen to twenty in four series. The *horny ring* of the large suckers has twenty-five to thirty teeth in its distal semicircle; those of the smaller about ten.

The *Surface* is smooth, except for a few irregular inconstant papillæ on one side of the ventral surface and below the eye.

The *Colour* is a pale yellowish grey, darker above.

The *Shell* is oval in *outline*, broadest anteriorly to the middle, tapering somewhat rapidly in front and ending in a semicircle; posteriorly it tapers gently, and, then rounding off, ends in two almost straight lines, which meet at a right angle at the base of the spine. The *chitinous margin* extends but slightly over the *dorsal surface*, which shows two grooves diverging as they pass forwards, separating three ribs, and is covered with rounded papillæ arranged in curves parallel to the anterior margin. The *ventral surface* has a rather deep and broad median groove: the *last loculus* occupies one-third of its extent, and is bounded posteriorly by a wavy line with three parts; the *striated area* is hollowed, so that this part of the shell is thin: the *inner cone* commences by two limbs, which arise half-way along the striated area, curve outwards and unite below the posterior apex with a broad chitinous band passing from one side of the shell to the other and forming a rather deep *outer cone:* the *spine* is short (but has been broken off); it bends slightly upwards and has a narrow longitudinal keel on its ventral surface.

Hab. South of Papua (Station 188), in 28 fathoms. Two specimens, ♀.

Sepia cultrata, Steenstrup MS.

Sepia cultrata, Steenstrup MS.
,, ,, Hoyle, *Ann. and Mag. Nat. Hist.* ser. 5, vol. xvi. p. 198, 1885.

The *Body* is elongated, broadest about the middle of its length. The *fins* are rather narrow, about one-fourth the breadth of the body, commencing 2 millim. from the anterior edge of the body and approaching within 5 millim. of each other posteriorly; the left is somewhat broader than the right. The *mantle-margin* extends far over the head dorsally and is not emarginate but slightly undulating ventrally. The *siphon* is short, terminating far short of the depression between the ventral arms.

The *Head* is broad, and the *eyes* very prominent.

The *Arms* are subequal, the order of length being 4, 3, 1, 2; they are one-fourth the length of the body, all are flattened and taper evenly to fine points. The *suckers* are in four series, except in the right dorsal arm, where they appear to be in two, probably owing to its state of extreme compression; they are of medium size, many are deeply notched proximally and distally, and provided with fine meridional grooves on the margin: the *horny ring* is smooth and surrounded by a papillary area. The *hectocotylus* is not developed. The *umbrella* is small, widest between the lateral arms, where it reaches up to the sixth or seventh row of suckers. The *buccal membrane* has five distinct points, the ventral edge being thickened and forming a large folded *spermatic cushion;* it bears no suckers. The *outer lip* is thick, and marked with fine longitudinal grooves; the *inner* is papillate.

The *Tentacles* are as long as the mantle, with a three-sided flattened *stem*, much broader proximally than distally. The *club* is slightly expanded, with a narrow protective membrane below, a broad one above, and a distinct web outwardly. There are five or six series of *suckers*, slightly larger in the middle than at the margins, on very long slender peduncles : the *horny ring* is smooth.

The *Surface* bears a number of small irregularly scattered papillæ, and four or five elongated warts near the origin of the fins on the dorsum, and some folds in the skin on the ventral surface; probably these are due to contraction.

The *Colour* is a dull grey with a bluish shade above inclining to yellow below.

The *Shell* has an elongate oval *outline*, broadest one-third of the way back and rounded off at both ends. The *chitinous margin* is narrow anteriorly, then broader, evanescent posteriorly, a deep calcareous ridge forming the posterior extremity of the shell; it extends very little over the *dorsal surface*, which bears only faint indications of a median ridge, and is beset with fine granules disposed in rows parallel to the anterior margin. The *ventral surface* is elevated so as to give the shell a more than average thickness: the *last loculus* occupies one-third the surface and is bounded by a transverse hemielliptical curve : the *striated area* is excavated, but slightly convex in the middle line. The *inner cone* consists only of the slightly elevated limbs, which run along three-quarters of the striated area and unite with each other as a flattened fillet posteriorly. The *spine* has lost its extreme point, but is strong, and has raised a knife-like ridge developed upon its ventral aspect.*

Hab. Off south-east coast of Australia (Station 163), depth 2200 fathoms. One specimen, ♀.

METASEPIA, subgen. nov.

Sepia (*Metasepia*) *Pfefferi*†, Hoyle.

Sepia (*Metasepia*) *Pfefferi*, Hoyle, *Ann. and Mag. Nat. Hist.* ser. 5, vol. xvi. p. 199, 1885.

The *Body* is short and stout, broadest about the middle of its length, very thick (dorso-ventrally), and bluntly rounded behind.

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* Whence the specific name.

† Named after Dr Georg Pfeffer of the Hamburg Museum.

The *fins* are one-fourth as broad as the body, and placed much nearer the dorsal than the ventral surface; they commence 2 to 3 millim. from the anterior margin and are connected by a narrow fillet behind; a slightly raised ridge passes down the ventro-lateral aspect of the body, similar to that seen in many specimens of *Octopus* and *Eledone* (possibly due to contraction). The *mantle-margin* projects very slightly dorsally, and is a trifle emarginate opposite the funnel: the *connective cartilages* are deeper than in most species of *Sepia*, but there is no distinct knob as in *Sepiella*. The *siphon* reaches up to the depression between the ventral arms.

The *Head* is broad, and the *eyes* prominent.

The *Arms* are subequal, in order of length 3, 4, 2, 1; they are rather more than half as long as the body and distinctly three-sided, having a ridge on the outer side of each, broadest on the ventral ones; they taper evenly to very fine points; the inner surface of each is roughly papillate and has hemispherical depressions into which the suckers are retracted. The *suckers* are in four series throughout, almost hemispherical, not very oblique, and marked with meridional grooves: the *horny ring* bears irregular square teeth. The *hectocotylus* is not developed. The *umbrella* is larger than usual in the genus, reaching on an average about one-third up the arms: the *buccal membrane* has seven not very prominent points, and there is a *spermatic cushion* as usual: the *outer lip* is very thin, the *inner* thick and papillate.

The *Tentacle* is about as long as the body, stout, indistinctly three-sided, and tapering. The *club* is short and but little expanded, with a narrow protective membrane on its outer side; the sucker-bearing area is, as it were, undermined on its inner aspect by a deep groove or fissure, and internally to this again is a broad fin which reaches down the tentacle for a distance exceeding half the length of the club. There are three *suckers* much longer than the rest, whereof the middle one is the largest and the proximal the next, placed on stout peduncles arising in deep depressions; towards the outer side of the club is a series of about four medium-sized suckers, and beyond these again one or two series of minute ones. The *horny rings* appear smooth under a powerful lens.

The *Surface* is smooth in general, but there are a few irregular papillæ in the ventro-lateral region.

The *Colour* is a dull grey, with indications of annular markings on the back.

The *Shell* has a rhomboidal *outline*, with rounded anterior and lateral angles; the *chitinous margin* is narrow, widest behind, where it forms a flat, acute-angled plate, the posterior extremity of the shell; it covers entirely, however, the *dorsal surface*, which is slightly raised mesially and marked by a number of faint striæ radiating from the posterior end. The *ventral surface* is much elevated on either side of a median groove; the *last loculus* occupies one-sixth of the surface, is bounded by a wavy line, and deeply emarginate in the middle. The *inner cone* is represented only by a narrow rib reaching half-way along each posterior side of the shell and meeting its fellow in a rounded angle behind, from which a number of radiating calcareous streaks pass outwards into the horny termination.

Hab. South of Papua (Station 188), 28 fathoms. One specimen, ♀.

ŒGOPSIDÆ.

Histiopsis, Hoyle.

Histiopsis, Hoyle, 1885. Narr. Chall. Exp. vol. i. p. 273 (*nomen tantum*).

Resembles *Calliteuthis*, Verrill, in the shape of the body and fin and in the pigment spots scattered over it, but has a web extending for some distance between the dorsal, dorso-lateral, and lateral arms: the suckers are in two series. The siphon has a suspensory ligament and a valve. The gladius has not been removed.

Histiopsis atlantica, Hoyle, (*loc. cit.*).

Histiopsis atlantica, Hoyle, *Ann. Mag. Nat. Hist.* ser. 5, vol. xvi. p. 201, 1885.

The *Body* is short, conical; acuminate and curving gently downwards posteriorly. The *fin* is about one-third the length of the body, and considerably broader than long; each half is roughly semicircular, and narrows in to its insertion both in front and behind. The *mantle-margin* is in general transverse, but projects slightly as a blunt rounded angle in the dorsal median line. The *mantle-connective* consists of a groove with a narrow fillet in the mid-dorsal line fitting into a corresponding median cartilaginous surface on the back of the neck, and of a long linear ridge extending up to the margin, which fits into a shorter groove on the base of the *siphon;* this is broad, short, and conical, has a thick suspensory ligament, through the skin of which two muscles may be distinguished, and a distinct valve.

The *Head* is as large as the body, rounded at the sides and flattened above and below. The *eyes* appear to have been enormous, one is distended and protrudes from its orbit, whilst the other is shrivelled. There is no auricular crest nor preocular pore, but behind each eye is a white papilla.

The *Arms* are about equal in length to the head and body together; the dorsal are the shortest, the other three pairs subequals, the order of length being 3, 4, 2, 1; they are quadrilateral, with rounded angles externally, with two slightly raised ridges internally, on which the suckers are situated; they taper gradually to very slender tips; the third pair have a delicate narrow web along the third quarter of their outer aspect. The *suckers* are in two series throughout; they are small and distant along the proximal third (the webbed portion) of the arms, then larger and closer, and finally minute and very closely set towards the tips; they are set transversely on short conical peduncles, spheroidal with a swollen band round the face. The *horny ring* is smooth proximally, distally it bears about five close-set, broad, bluntly rounded teeth. No trace of a *hectocotylus* could be found. The *umbrella* is found only between the dorsal, dorso-lateral, and lateral arms; it takes origin from the sucker-bearing ridge and extends about one-third up the arm. The *buccal membrane* is broad and somewhat contracted over the mouth; it has the usual seven points, but they are very blunt and indistinct; it is united by three ligaments with the web between the dorsal and dorso-lateral arms, by a ligament with the inner side of each ventro-lateral arm on its ventral aspect and by another to the inner surface of each ventral arm, there being altogether seven ligaments. The membrane bears no suckers; its inner surface is much creased and folded. The *outer lip* is very thin and smooth, and hidden between the creased integument of the buccal membrane and the *inner lip*, which is thick and marked with irregular radial grooves.

The *Tentacles* have been removed; the stumps which remain are not half the length of the arms; they are quadrangular and flattened from above downwards.

The *Surface* bears a large number of papillæ, slightly elevated, resembling those of *Calliteuthis;* they are arranged most thickly on the ventral aspect of the head and body, but also on the dorsal, and extend up the outer aspect of the arms, three series on the ventral arms, two on each of the others. Near the tip of each dorsal arm is a series of four or five black, elongate, egg-shaped swellings, gradually diminishing in size, and forming apparently an extreme development of the papillæ above mentioned. The second pair of arms appears to have been similarly provided; the third has been so stripped of integument towards the tips that it is impossible to ascertain their original condition. In the fourth the warts at the tip are quite similar to those lower down the arm.

The *Colour* is a dull purplish madder, paler above than below, the papillæ are a deep black, with a white centre, usually situated towards the anterior margin. The *buccal membrane*, both sides of the umbrella, and the inner surfaces of the arms, so far as this extends, are a deep purple.

The *Gladius* has not yet been extracted from the solitary individual.

Hab. South Atlantic (Station 333), 2025 fathoms. One specimen, sex ?

BATHYTEUTHIS, Hoyle.

Bathyteuthis, Hoyle, Narr. Chall. Exp., vol. i. p. 272, May 1885.
Benthoteuthis, Verrill, Trans. Connect. Acad., vol. vi. p. 401, July 1885.

Body long, cylindrical, tapering but slightly behind; *fins* subterminal, small and rounded; *mantle-connective* an elongated linear ridge fitting into a similar shorter groove on the base of the siphon, which is provided with a valve, but has no dorsal bridles.

Head large, very broad, with prominent eyes.

Arms very short, slender and conical; suckers very minute and in two series. *Buccal membrane* large, with seven points, each bearing one or two suckers.

Tentacles long, slender, without clubs, but with numerous minute suckers.

Gladius, resembling that of *Ommastrephes* in front, but expanded in the posterior third.

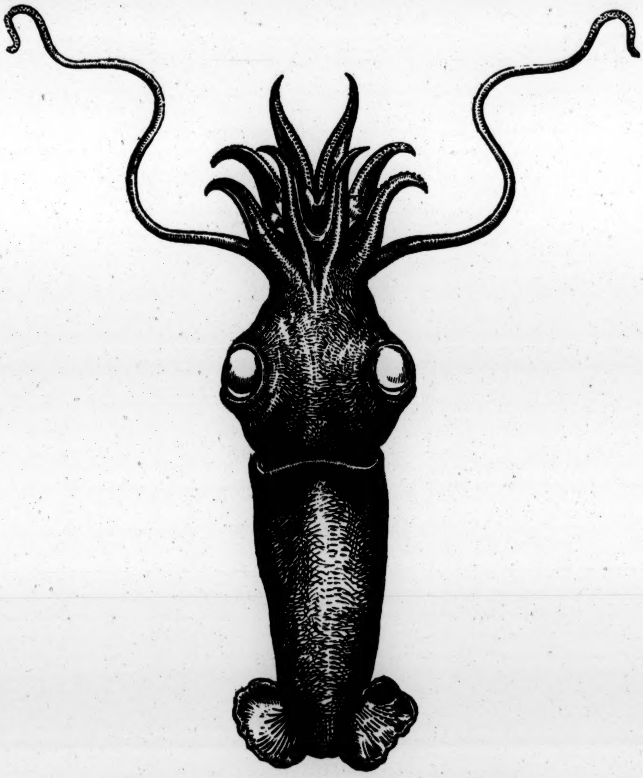

FIG. 2.—*Bathyeuthis abyssicola*, Hoyle.

Bathyteuthis abyssicola, Hoyle.

Bathyteuthis abyssicola, Hoyle, Narr. Chall. Exp., vol. i. p. 272, fig. 108, 1885.

The *Body* is subcylindrical, somewhat narrowing towards and bluntly rounded at the posterior extremity. The *fins* are small, separate; each is somewhat rectangular in shape, with rounded angles, and attached to the body by one angle.

The *mantle-margin* is almost transverse, but projects slightly in the dorsal median line, and forms a shallow sinus behind each eye and the siphon. The *mantle-connective* consists of a long linear ridge, extending quite to the margin, and fitting into a similar but somewhat shorter and broader groove on the base of the *siphon*, which is short, tapering, and bluntly pointed, fits into a shallow depression below the head, but has no dorsal bridles.

The *Head* is much broader than the body, being distended laterally by the enormous eyes which look outwards and forwards, and have bright, prominent, glistening lenses.

The *Arms* are unequal, the order of length being 4, 3, 2, 1, and about one-fourth the length of the body: they are all conical and taper to slender points; each has a distinct angle along the outer side, which expands to a distinct web in the fourth pair; there is also a very narrow delicate web along each side of the sucker bearing face. The *suckers* are very minute, pedunculate, and are arranged in two rows, almost embedded in the arm: they are spheroidal, and have a smooth horny ring, surrounded by two or three rows of conical papillæ. The *hectocotylus* was not present. The *buccal membrane* is very large, has the usual seven points, connected by ligaments with the arms; each joint bears one or two suckers.

The *Tentacles* are almost equal in length to the head and body together; the *stem* is very slender, cylindrical, and grooved along the inner aspect; they taper away rapidly towards the extremity, no *club* being formed: the *suckers* cover only the distal eighth of the tentacle in its inner aspect; they are smaller than those of the sessile arms, and almost imperceptible to the naked eye; they are urn-shaped, and have a smooth horny ring, surrounded by about two rows of very small papillæ.

The *Surface* is covered with minute wrinkles, probably due to the action of the spirit.

The *Colour* is a very deep purplish brown.

The *Gladius* was unfortunately somewhat damaged; for the anterior two-thirds it resembles that of an *Ommastrephes*, but posteriorly it expands into a broad blade, resembling that of *Loligo;* it was impossible to ascertain whether it forms a terminal cone.

Hab. Southern Ocean (Station 147), 1600 fathoms. One specimen, sex ?

7. Some Stereoscopic Photographs, &c., were exhibited by the Astronomer Royal for Scotland.

Monday, 20th July 1885.

DAVID MILNE-HOME, Esq., LL.D., Vice-President,
in the Chair.

The following Communications were read:—

1. On Patella. Part II. By Dr Harvey Gibson.

2. On the Unifilar Knots with Ten Crossings. By the Rev. T. P. Kirkman, F.R.S.* Communicated by Professor Tait.

3. Census of Ten-fold Knottiness. By Professor Tait.

4. On the Thermal Effects produced, in Solids and in Liquids, by sudden large Changes of Pressure. By Messrs H. G. Creelman, B.A., and J. Crocket. Communicated by Professor Tait.

In several papers communicated to the Society within recent years the thermal effect of compressing water has been dealt with by various observers. The present paper gives the results of experiments of a similar kind to ascertain the thermal effects of compressing certain solids and liquids. These experiments were conducted in the University of Edinburgh, under the superintendence of Professor Tait.

Pressure was applied by forcing water by means of a powerful force pump into a strong steel tube, called the "small gun" (shown in section in the accompanying figure). Within this, a thermo-electric junction of nickel and iron wires was placed, most of the wire within the gun being in the form of a coil, so that the junction could be drawn up and pushed down as required. The wires passed out of the gun between two well-oiled leather discs, which could be tightly screwed together between a steel plate and a similar one forming the lower part of the gun. The nickel wire formed, with an iron wire, another junction, called the "outer junction," which was kept in water at a uniform temperature. The two iron wires were connected with a Thomson's dead-beat galvanometer (resistance

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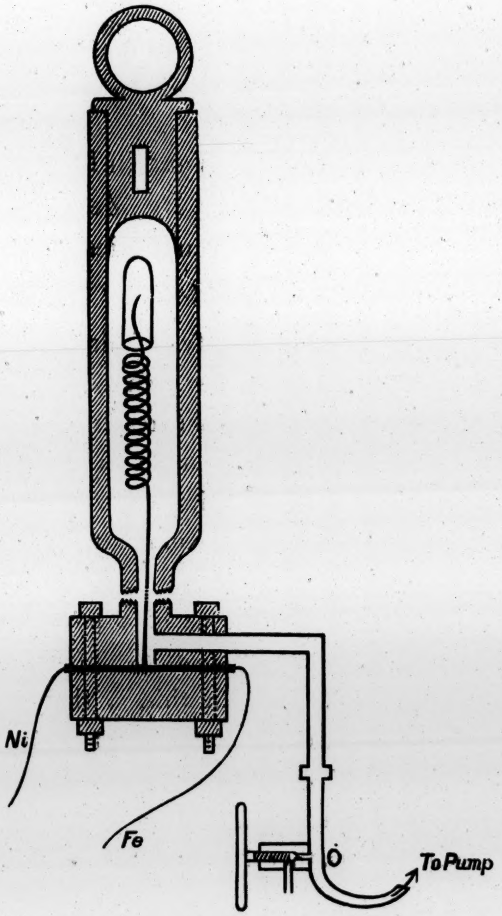
* A Supplement to this paper will be printed after the Proceedings for July 20.

1·5 ohms at 10° C.). When the wires were reversed the deflections differed by about 1 per cent. The upper orifice of the gun was closed with a steel plug, of the form shown in the diagram, and secured by a slot passing through plug and gun. At the lower orifice was a tap to allow of a sudden release of pressure. The gauge for measuring the pressure has been already described, and a figure of it will be found in the "Challenger" Commission Report.



In experimenting on solids our method was simply to fix tightly a piece of the substance two centimetres long by one square cm. in section on the inner junction. In the case of viscous solutions and liquids heavier than water, we arranged a small test tube within the coil, so that the inner junction dipped down into the tube, and was surrounded on all sides by the liquid. For liquids lighter than water we inverted the tube as shown in the figure, and having filled the gun with water, sucked out the air with a narrow U tube, and then admitted the liquid to be tested by a pipette.

A pressure of three tons on the square inch could be applied almost instantaneously by two strokes of the pump handle; the deflection of the galvanometer was simultaneously taken, and when the spot of light had steadied, the pressure was let off instantaneously, the deflection of the galvanometer being observed. The data for converting these deflections into degrees centigrade were obtained from experiments made from time to time to determine the deflection arising from known changes of temperature of the outer junction. The galvanometer was delicate enough to enable us to measure differences of temperature amounting to less than ·01 degree centigrade, and yet not so sensitive as to be seriously affected by the traffic in the street without. Each result recorded below is the mean of at least five experiments; in the case of pressures of about two tons each result is usually the mean of ten. 22·5 divisions of the pressure gauge correspond to a pressure of one ton on the square inch, or about 150 atmospheres.

Each day, with the exception of those on which we found the exact value of galvanometer readings by observing the result of known changes of temperature of the outer junction, it was our habit to take a series of observations for water alone, by means of which we could verify the previously ascertained equivalent of galvanometer readings.

It was generally observed that the fall of temperature on relaxation of pressure was greater than the corresponding rise on applying pressure, owing to some extent to the fact that pressure could be more suddenly relieved than applied. In the case of water, we observed, as the mean result of many experiments, that the two differed in the proportion of about 14 to 13. Thus, on applying a pressure of two tons on the square inch, we obtained a deflection of 1·3, equivalent to 0°·31 C.; while on releasing pressure the deflection was 1·4, equivalent to 0°·33 C. This at a temperature of 16° C., at which, by Sir W. Thomson's formula, the rise of temperature should be 0°·35 C.

Some reduction thus seems necessary of the results given in the tables below, though not in the same proportion, since convection currents present in the considerably large quantity of water which filled the gun, would be wanting in the solids and the comparatively small quantities of liquids used.

To furnish an idea of the general agreement in the results, we give the full data from one experiment, taken at random; namely, the effect produced in vulcanite by changes of pressure to the extent of about two tons on the square inch.

Effect on applying Pressure.		Effect on relieving Pressure.	
Change of Pressure.	Deflection Positive.	Change of Pressure.	Deflection Negative.
48	2·9	45	2·7
47	2·8	44	2·6
44	2·6	41	2·5
41	2·5	37	2·2
44	2·7	41	2·5
47	2·7	43	2·5
43	2·5	39	2·3
45	2·6	41	2·5
48	2·8	43	2·6
45·2	2·68	41·6	2·5

Thus taking the mean of nine experiments, and having found, in the manner referred to above, that 4·8 divisions on the galvanometer scale are equivalent to 1° C., we deduce the rise of temperature on applying $\frac{45·2}{22·5}$ tons on the square inch, to be 0°·56 C., and the fall on relieving $\frac{41·6}{22·5}$ tons to be 0°·52 C. Hence we can deduce the rise or fall per ton, as shown in the table under *Vulcanite.*

Cork.—A parallelepiped, two centimetres long and one square centimetre in section, was cut from a piece as homogeneous as could be obtained. A reference to the following table will show that, for this substance, the fall of temperature on relieving pressure is considerably less than the rise on application of pressure. This result had been given by Professor Tait in a Note in the *Proceedings* (May 16, 1881), and it was to some extent with a view to the discovery of like anomalies that the present investigation was undertaken. But no other of the substances which we have tested showed this peculiarity. Each of the following results is the mean of six experiments :—

Temp. in Degrees Centigrade.	Thermal Effect on applying Pressure.				Thermal Effect on relieving Pressure.			
	Pressure.	Deflection.	Temp. Raised.	Rise per Ton.	Pressure.	Deflection.	Temp. Lowered.	Fall per Ton.
15°	22·3	3·6	0°·75	0°·75	23·2	2·5	0°·53	0°·51
15°·3	45·2	6·2	1°·3	0°·65	44·5	4·3	0°·9	0°·45
15°·6	65·6	8·2	1°·71	0°·59	59·5	5·4	1°·12	0°·42

Vulcanite.—The first specimen employed was a parallelepiped, two centimetres long and one square centimetre in section. The following is a table of the results :—

Temp. in Degrees Centigrade.	Thermal Effect on applying Pressure.				Thermal Effect on relieving Pressure.			
	Pressure.	Deflection.	Temp. Raised.	Rise per Ton.	Pressure.	Deflection.	Temp. Lowered.	Fall per Ton.
16°	26	1·66	0°·35	0°·30	22·4	1·4	0°·3	0°·30
16°·3	45·2	2·68	0°·56	0°·28	41·6	2·5	0°·52	0°·28
16°·6	67	4·0	0°·83	0°·28	61	3·7	0°·79	0°·28

We also tested the vulcanite used to protect the "Challenger" Expedition thermometers. The specimen employed was a cube of one centimetre. The following table shows slightly greater results than were obtained with the first specimen :—

Temp. in Degrees Centigrade.	Thermal Effect on applying Pressure.				Thermal Effect on relieving Pressure.			
	Pressure.	Deflection.	Temp. Raised.	Rise per Ton.	Pressure.	Deflection.	Temp. Lowered.	Fall per Ton.
16°·6	25	1·6	0°·37	0°·33	22·5	1·4	0°·33	0°·33
16°	45·6	2·72	0°·63	0°·31	45	2·86	0°·66	0°·33
16°·3	66	3·6	0°·83	0°·28	55	3·4	0°·79	0°·32

Glass.—The specimen employed was a cylinder of common lead glass, two centimetres long and one in diameter. The bore into which the junction fitted was filled with powdered glass, so that as little water as possible might intervene between the junction and the glass. The following is a table of the results :—

Temp. in Degrees Centigrade.	Thermal Effect on applying Pressure.				Thermal Effect on relieving Pressure.			
	Pressure.	Deflection.	Temp. Raised.	Rise per Ton.	Pressure.	Deflection.	Temp. Lowered.	Fall per Ton.
14°·6	24	0·6	0°·13	0°·12	24	0·64	0°·13	0°·12
15°	49	1·35	0°·28	0°·13	47	1°·45	0°·3	0°·14
	66·4	1·87	0°·39	0°·13	65·2	1·97	0°·41	0°·14
	58·4	1·66	0°·34	0°·13	58·6	1·74	0°·36	0°·14

The following tables give results for other substances treated in the same way as cork and vulcanite :—

Pure India-rubber.

Temp. in Degrees Centigrade.	Thermal Effect on applying Pressure.				Thermal Effect on relieving Pressure.			
	Pressure.	Deflection.	Temp. Raised.	Rise per Ton.	Pressure.	Deflection.	Temp. Lowered.	Fall per Ton.
14°·6	29	5·1	0°·95	0°·74	22·3	4·3	0°·8	0°·79
	46	7·7	1°·42	0°·70	38	7·2	1°·33	0°·79
	64	10·9	2°·0	0°·70	49·4	9·6	1°·8	0°·80

Vulcanised India-rubber.

16°	26	3·55	0°·72	0°·64	19·2	2·85	0°·6	0°·70
	45·4	6·3	1°·3	0°·64	38·7	5·6	1°·16	0°·67
	66	8·9	1°·8	0°·61	56	7·9	1°·6	0°·64

Gutta-percha.

16°	22·5	3·0	0°·65	0°·65	22·5	3·1	0°·67	0°·67
	46·6	5·66	1°·23	0°·60	46·6	6·08	1°·32	0°·64
	66	7·8	1°·7	0°·58	66	8·9	1°·9	0°·63

Beeswax.

15°	23·4	3·94	0°·86	0°·83	23	3·86	0°·84	0°·83
	47	7·6	1°·65	0°·79	43·6	7·8	1°·7	0°·86
	66·4	10·6	2°·3	0°·78	60·6	10·9	2°·4	0°·89

Solid Paraffin.

14°	25	3·94	0°·61	0°·56	24·4	4·0	0°·62	0°·57
	45	7·2	1°·12	0°·56	45	7·6	1°·18	0°·59
	67	10·4	1°·62	0°·54	65	11·26	1°·76	0°·61

Marine Glue.

Temp. in Degrees Centigrade.	Thermal Effect on applying Pressure.				Thermal Effect on relieving Pressure.			
	Pressure.	Deflection.	Temp. Raised.	Rise per Ton.	Pressure.	Deflection.	Temp. Lowered	Fall per Ton.
15°·5	33·6	4·76	1°·36	0°·91	30·8	4·7	1°·34	0°·98
	47·4	6·24	1°·78	0°·85	45	6·26	1°·79	0°·90
	66	8·4	2°·4	0°·82	45·7	6·45	1°·84	0°·91

Turning our attention, in the next place, to colloids, we examined common glue in three forms—(1) the brittle form in which it is usually sold; (2) as a dry jelly; and (3) as a viscous liquid, which poured with difficulty. The following table shows the results:—

Glue (Brittle).

Temp. in Degrees Centigrade.	Thermal Effect on applying Pressure.				Thermal Effect on relieving Pressure.			
	Pressure.	Deflection.	Temp. Raised.	Rise per Ton.	Pressure.	Deflection.	Temp. Lowered.	Fall per Ton.
18°	24·4	1·8	0°·42	0°·39	22·5	1·8	0°·42	0°·42
	45·2	2·94	0°·68	0°·34	44·5	3·44	0°·8	0°·40
	46·6	3·24	0°·75	0°·36	45	3·66	0°·84	0°·42
	67·4	4·5	1°·05	0°·35	67	5·3	1°·22	0°·41

Glue (Jelly).

16°	24·4	1·67	0°·36	0°·33	24·1	1·67	0°·36	0°·33
	45	3·1	0°·68	0°·34	44	3·3	0°·72	0°·36
	65	4·8	1°·04	0°·36	64	5·1	1°·11	0°·39

Glue (Viscous Solution).

17°	23	1·02	0°·24	0°·23	23·1	1·06	0°·25	0°·24
	45·7	1·91	0°·44	0°·22	45	2·17	0°·50	0°·25
	67·6	2·9	0°·67	0°·22	67·3	3·36	0°·78	0°·26

We also examined gelatine in the form of a dry jelly, isinglass as a jelly wet to the touch, and gum arabic as a viscous solution. The following were the results obtained :—

Gelatine.

Temp. in Degrees Centigrade.	Thermal Effect on applying Pressure.				Thermal Effect on relieving Pressure.			
	Pressure.	Deflection.	Temp. Raised.	Rise per Ton.	Pressure.	Deflection.	Temp. Lowered.	Fall per Ton.
15°	24·4	1·34	0°·29	0°·27	24·1	1·26	0°·27	0°·25
	47	2·5	0°·54	0°·26	47	2·7	0°·58	0°·28
	67	3·4	0°·74	0°·25	63	3·6	0°·78	0°·28

Isinglass.

14°·3	21·4	1·0	0°·21	0°·22	22	1·0	0°·21	0°·22
	48	2·04	0°·43	0°·21	48	2·24	0°·47	0°·22
	67·5	3·0	0°·65	0°·22	66	3·0	0°·65	0°·22

Gum Arabic.

17°·3	24·2	1·81	0°·39	0°·36	24·2	1·88	0°·41	0°·38
	45·7	3·27	0°·71	0°·35	44·6	3·5	0°·76	0°·38
	66·9	4·69	1°·02	0°·35	66·1	5·25	1°·14	0°·39

Chloroform (*Specific Gravity*, 1·497).

15°·5	23·3	6·25	1°·49	1°·44	22·5	6·1	1°·45	1°·45
17°	46	11·46	2°·73	1°·34	45	12·2	2°·90	1°·45
	66	16·2	3°·85	1°·31	69	19	4°·52	1°·47

The following liquids, lighter than water, were examined in the manner already explained :—

Paraffin Oil.

Temp. in Degrees Centigrade.	Thermal Effect on applying Pressure.				Thermal Effect on relieving Pressure.			
	Pressure.	Deflection.	Temp. Raised.	Rise per Ton.	Pressure.	Deflection.	Temp. Lowered.	Fall per Ton.
18°	24·3	6·4	1°·49	1°·39	23·7	6·37	1°·46	1°·39
16°	44·3	10·5	2°·44	1°·22	45	10·8	2°·51	1°·25
19°	45·7	11·7	2°·74	1°·34	44	12·2	2°·84	1°·45

Florence Oil.

19°·3	23·5	5·66	1°·3	1°·26	23	5·58	1°·29	1°·26
20°·8	47·2	11·02	2°·62	1°·24	47·2	11·8	2°·81	1°·34
21°	63	14·6	3°·48	1°·24	67·1	16·8	4°·0	1°·34

Linseed Oil.

19°·5	22·5	5·0	1°·19	1°·19	22·3	5·1	1°·21	1°·21
16°·6	45	8·0	1°·90	0°·95	45	8·2	1°·95	0°·96
	68	11·9	2°·83	0°·94	68·5	12·35	2°·94	0°·96

Castor Oil.

	27	3·9	0°·93	0°·78	25·6	3·75	0°·89	0°·78
	49	6·4	1°·52	0°·69	47	6·6	1°·57	0°·75

Sulphuric Ether.

21°	23·3	7·9	1°·9	1°·8	22·5	8·0	1°·9	1°·9
	46·2	15·04	3°·58	1°·74	45	15·44	3°·67	1°·83
	70	22	5°·2	1°·67	66·5	21·5	5°·1	1°·73

5. On a Method of Measuring the Resistance of Electrolytes without endeavouring to prevent Polarisation. By Mr W. Peddie.

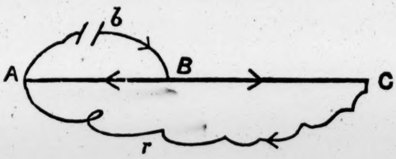
In the case of a metallic conductor the resistance may be got at once by means of Ohm's Law. But when the conductor, the resistance of which is to be determined, is an electrolyte, the electromotive force acting along the circuit is only partly employed in producing the current. So that we obtain the equation

$$E = Rx + P,$$

where E is the electromotive force, R the resistance, x the current, and P the reverse electromotive force of polarisation. Since, for a considerable stretch of values of the current, P seems to be proportional to it, we may write

$$E = (R + p)x,$$

where p is a constant for the given values of x. That is to say, if the ordinary method of measuring resistance could be used, what would be measured is the actual resistance *plus* an unknown quantity. Hence, in most methods of experimenting, alternating currents, or non-polarisable electrodes, are used so as to prevent polarisation. In Horsford's method, p is eliminated by giving R different values, while x remains constant. The difficulty here consists in the fact that polarisation may not be the same in both cases, for the nature of the solution at the electrodes may be different because of the liberated ions. The object of this paper is to describe a method of measuring the resistance which is free from this objection. The annexed diagram will show the arrangement. ABC represents an electrolytic conductor, with one pole of a battery (b) joined to an electrode at B, while the other is joined to an electrode at A, which in turn is joined to a similar electrode at C by a metallic conductor of resistance r. The current may be supposed to flow in the directions indicated by the arrow-heads. Let A, B, C represent the potentials at these points, and let x be the current flowing from B to A, and y be the current flowing from B to C, while R is the resistance between A and B, and $R + \rho$ is that between B and C. We have then



$$\begin{aligned} B - A &= (R + p)x, \\ B - C &= (R + p + \rho)y, \\ C - A &= ry. \end{aligned}$$

Hence we obtain

$$R + p = \frac{\rho + r}{\frac{x}{y} - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Now, placing the battery between B and C, we get similarly

$$R + p + \rho = \frac{r - \rho}{\frac{x'}{y'} - 1} . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

when x' and y' are the currents corresponding to x and y in the previous arrangement. From (1) and (2) we get

$$\rho = r \frac{xy' - yx'}{xx' - yy'} . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Hence the difference between the resistances of the two parts of the electrolyte may be calculated in terms of a known resistance and of known currents. In this form of the experiments, however, it is assumed that polarisation is proportional to the current density. Also there is the objection that heating is going on, usually to different extents, in the two parts, because of the currents being different. Both these sources of error vanish if x' is equal to y', and then equation (3) reduces to

$$\rho = r .$$

I have as yet made only a very rough series of experiments with the view of testing the steadiness of the currents, but it seems to indicate that the method will be successful. The form in which the experiments were conducted is that to which equation (3) applies. In addition to the errors above indicated as affecting the results, there were causes tending to produce large variations arising from the roughness of the apparatus set up provisionally. Three cylindrical glass cups were connected in series by two glass tubes inserted near their lower edge. The electrolyte (a 5 per cent. aqueous solution of sulphuric acid) was poured into this arrangement, and the electrodes (platinum) dipped into it through the open ends of the cups. The cups were of large volume, so that the resistance of the portion of liquid between the electrodes and the extremities of the tubes could be neglected. The lengths of the tubes were 9·2 and 8·5 centimetres respectively, and their diameter was ·65 centimetre. The metal wire used to connect the extreme electrodes had a resistance of ·95 ohms. A battery of four Bunsen cells was found necessary to produce a current. The following figures show the readings, on a tangent galvanometer, of the deflections produced by the currents $x'+y'$ and y' respectively:—

22°·8	23°·1	22°·9	22°·9	23°·1	23°.1
13°·1	13°·1	12°·8	13°·0	12°·9	13°·1

This series of readings is one of the most unsteady obtained, and it was found on testing that most of the variations might be due to alteration of the electromotive force of the battery employed, or to alteration of contact at the various junctions of the circuit. The next set of figures are values of the ratios $\frac{x}{y}$ and $\frac{x'}{y'}$ respectively.

1·25	1·19	1·245	1·19
0·811	0·840	0·846	0·87

The value of the specific resistance deduced from these observations agrees very closely with previous determinations by other methods.

Evidently the method may be used to investigate the laws of variation of polarisation with current density. For we have as above

$$ry = (\mathrm{R}+\rho)x - \mathrm{R}y + p_1 - p_2 \, .$$

And we may put generally

$$p = \mathrm{P} + \frac{1}{a} f(\gamma) \, ,$$

where $f(\gamma)$ is some function of the current γ, P is the E. M. F. required to decompose the electrolyte, and a is the area of the electrode. Hence, if $x=y$, we get

$$r = \rho + \left(\frac{1}{a} - \frac{1}{a'}\right) f(\gamma) \, .$$

So if $a=a'$ we get $r=\rho$. If now we make $a'k=a$ and adjust the currents to equality by altering ρ, we have

$$r = \rho' + \frac{1-k}{a} f(\gamma) \, ,$$

where ρ' is known in terms of ρ, so that $f(\gamma)$ is determinate.

Again, either of equations (1) or (2) may be used to find the value of p, which is the electromotive force of polarisation produced by unit current.

6. Note on the Contraction of the Auricles of the Pig's Heart.

By J. MacFadyean, M.B., B.Sc., M.R.C.V.S., and G. Sims Woodhead, M.D.

It is a familiar fact that the heart of cold-blooded vertebrates may continue to beat for a long period—even for days—after its removal from the body, but it is not so well known that contractions may occur in the heart of the higher vertebrates for a considerable time after death. On this latter point, however, there are many observations on record. Harvey noted that rhythmical contractions continued in the heart of the pigeon for some time after death, and, further, that after it had ceased to beat, it recovered its vigour, and both auricles and ventricles pulsated on the application of a stimulus, such as the tip of the finger wetted with saliva.*

Lewes also quotes from Donders, that "Harless observed it (the heart) beating in the body of a decapitated murderer one hour after execution. Margo found the right auricle beating two hours and a half after the execution, although not a trace of irritability could be detected in the other parts of the heart. Dietrich, Gerlach, and Herz found that both ventricles contracted if one was irritated forty minutes after death." The same author further quotes, from Emil Rousseau, the case of a woman whose heart had these rhythmic movements seven-and-twenty hours after she had been guillotined. Landois † points out that numerous observations have been made by Pannum, Valentin, and others during recent years on the excised heart of rabbits, dogs, &c., and that even so early as 300 B.C. movements in an excised heart had been recorded by Cleanthes.

Our attention was specially drawn to this subject by the behaviour of a pig's heart which was obtained at the Edinburgh Abattoir for some inoculation experiments in connection with pig typhoid. At 10.25 A.M. the animal was killed in the way commonly practised by butchers, viz., by first stunning it by a blow on the cranium with a heavy mallet, and then by cutting across the great vessels at the root of the neck. It was allowed to bleed for a few minutes until apparently dead. The thorax was then opened, and the heart and lungs were cut out together. While this was being done, the heart was observed to give a few pulsations, which led the butcher to remark that the animal was not quite dead. A string was then firmly tied round the great vessels at the base of the heart, which was next separated from the lungs by cutting the vessels on the distal side of the ligature. The heart on being laid aside on a table began to pulsate slowly but rhythmically, the contractions taking place in both auricles and ventricles. After a few minutes spent in examining the remaining viscera of the animal, and of others killed at the same time, the heart and portions of other organs were wrapped up together, and carried to the University New Buildings, the Abattoir being left at 10·35.

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* *Physiology of Common Life*, by G. H. Lewes, vol. i. p. 334.

† *A Text-book of Human Physiology*, Landois and Stirling, vol. i. p. 96.

At 10.50, when the parcel was opened in the Pathological Laboratory, it was observed that spontaneous contractions were still occurring at intervals in the auricles of the heart. On stimulating the right auricle by slight scratching with a pin, a contraction of that cavity was easily obtained, and this was immediately followed by contraction of the left auricle. Stimulation of the left auricle produced a contraction of that cavity, but did not affect the right auricle. These experiments were repeated several times, and always with the same result.

Both auricles continued to beat spontaneously till 11.12, the contraction occurring first in the right, and this being followed immediately by a contraction of the left.

After 11.16 contractions of the left auricle were obtainable only by direct stimulation, the right auricle, however, continued to beat till 11.19.

At 11.28 fibrillary twitchings were obtained on slightly stimulating the posterior part of the right auricle, where it was still moist, and by increasing the stimulus, stronger contractions resulted.

At 11.33 the same results were obtained on stimulating the left auricle.

At 11.28, and again at 11.40, stimulation produced only fibrillary contraction.

At 11.44, on stimulating strongly the upper and inner part of the right auricle, a strong contraction resulted, with a peculiar tetanic appearance of the muscle along the line of stimulation. This part, as compared with the other parts, which had previously failed to respond on stimulation, had more blood beneath it in the cavity of the auricle, and it was also still moist on its outer surface.

Between 11.47 A.M. and 1.25 P.M. the left auricle was stimulated seventeen times, a contraction following each stimulus. In one instance, at 12.43, two strong contractions followed a single stimulus.

At 1.28, on slightly distending the right auricle by squeezing blood into and from the ventricle, contraction was obtained on stimulating any point, each contraction being circumscribed. At 1.38 contractions were fainter, and not obtainable at every point.

At 1.40, after fully distending the auricle, a very marked contraction followed, and extended along the whole inner border of the auricle.

At 1.50 a similar but less extensive contraction was obtained in the same way.

At 1.5 stimulation of the distended auricle produced a double contraction along its border, and strong but circumscribed contractions at several other points.

At 2.1 the empty auricle was stimulated, but without response. On distending the cavity, contractions at several points were obtained on stimulation.

At 2.6 the auricle was distended, and on stimulation some feeble contractions were obtainable, but only at a few points. The heart was immersed in water at 100° Fahr. for about one minute. On stimulation there was no response. The organ was next immersed in cold water (about 50° Fahr.), but no contractions could be obtained.

Summary.—Spontaneous contractions in left auricle for 47 minutes. Contractions could be induced in it on stimulation of right 4 minutes after this. It responded to direct stimulation for exactly 3 hours from the time the animal was killed. The right auricle continued to beat spontaneously for 54 minutes. It responded to stimulation for 3 hours and 41 minutes.

In another heart obtained at the same time, which was not otherwise examined, fibrillary contraction of the muscular wall of the right ventricle, near the auriculo-ventricular groove, was observed half an hour after death.

It seemed to us that this long continued contractility of the mammalian heart should have a most important bearing upon the question of resuscitation, after death from hæmorrhage, chloroform poisoning, and other forms of syncope, and we determined to make a series of experiments with the view of clearing up some points still under discussion. As yet we have had opportunity of making but one of these experiments, but we hope ere long to be able to communicate further observations. Immediately after we had formed this resolution an opportunity presented itself, but before we had made the necessary arrangements as to recording apparatus. The observation is of the roughest kind, but appears to us to be of sufficient importance to put on record.

An animal condemned for pig typhoid was killed as in the other case. It was noticed that the animal "bled" very slowly.

The heart was removed as rapidly as possible, and whilst all the cavities were still beating. In the meantime defibrinated sheep's blood, mixed with 2 parts of $\frac{3}{4}$ per cent. salt solution had been raised to a temperature of 99° Fahr.

A cannula (too small) was tied into one of the pulmonary veins, and connected by about 9 inches of elastic tubing with a similar cannula in the pulmonary artery. A third cannula was tied into the inferior vena cava, and another was fastened into the aorta. The superior vena cava was firmly ligatured at a distance of about three-quarters of an inch from the auricle. All these tubes were first filled with the blood mixture, as was also a "Higginson's" syringe, which was fitted on to the cannula in the inferior vena cava. These operations occupied 20 minutes, and by the time they were completed the ventricles had ceased to contract, and the auricles were beating very intermittently and feebly.

Warm blood solution was now pumped slowly and steadily into the right ventricle, and the heart was suspended in the same fluid. This was almost immediately followed by a full and regular contraction of both auricles, the beats being, as far as we could determine with the eye, quite synchronous. This went on regularly from 12.40 to 12.55, when the right auricle suddenly ceased to beat at all regularly, and only a few irregular contractions could be obtained on stimulating with the point of a needle. Whilst the auricle was contracting, the lower part of the superior vena cava (that part below the ligature) was also contracting regularly and firmly. This beat did not merge into that of the auricle, but was perfectly independent of it, and the cava continued to beat for at least two minutes after the auricular beat had ceased. Whilst the examination and stimulation of the right auricle and superior cava were going on, the heart had been withdrawn from the blood, and the distension had not been kept up.

At 1.30, on examining the left auricle, it also was found to have stopped contracting. It was stimulated with the point of a needle, but there was still no contraction. On removing the connecting tube from the pulmonary vein and immersing the heart, and pumping in blood solution until the left auricle was moderately distended, there were several distinct contractions which were repeated on touching the wall with the point of a needle. Similar contractions were obtained at 1.23, 1.24, and 1.26, on applying the point of a needle.

1.23, on stimulating the left auricle with the needle, slight fibrillar contractions were observed. On distending the cavity the contraction was more distinctly marked.

1.40, after distension, on stimulating with needle, several very strong wavy contractions were observed.

1.52, dead; not even a fibrillar twitching.

An attempt was made to induce contraction in the right auricle by distending, after the left auricle had been distended and had contracted, but without any effect; not even a fibrillar contraction after 12.55.

Summary.—The right auricle beat regularly for 35 minutes after the animal commenced to bleed to death, and 15 minutes after the heart was placed in blood. Irregular contractions continued for not more than a minute after this. Contraction of the superior vena cava continued for two minutes later. The left auricle beat regularly for about 55 minutes from commencement of the bleeding, and 35 minutes after the heart was placed in blood. More or less regular contractions could be *induced* for at least 25 minutes longer.

It will be seen, on comparison of the two cases, that contractions ceased much sooner in the heart specially prepared. It should be noted in this connection that there were two points of difference. (1) In the first case, tension was maintained in the cavities of the heart by the ligature which was applied whilst some blood remained in the organ; whilst in the second case the tension was kept up, irregularly and intermittently, by means of the "Higginson" syringe, and by stopping the outflow of the fluid at the various points in turn. (2) Whilst both pigs were diseased, the lesions were more pronounced in the viscera of the second animal, and the vitality of the tissues might be expected to be somewhat lower.

The points to be specially noted in the second case are—(*a*) that, contrary to what is usually observed, movements were arrested in the right auricle before those in the left had ceased; (*b*) that the contraction of the superior vena cava was quite independent of that of the auricle, a contraction occurring before each contraction of the auricle.

The latter observation coincides with those quoted from Haller and Nysten by Landois, *loc. cit.*, p. 69:—"Independent rhythmical contractions of the venæ cavæ and pulmonary veins are often noticed after the heart has ceased to beat."

Stirling also notes that such contractions can be observed in the veins of the rabbit after the heart is cut out of the body.

The contraction of the superior vena cava was so distinct and forcible that it suggested to us the idea that it might, under certain conditions, be sufficient to produce a distinct sound which might be referred to the orifice.

It is interesting to note, in connection with this contraction, that we were able to trace striped muscular fibre in the wall of the superior vena cava at least 1¼ inch from the orifice.

7. On the Heats of Combination of Zinc and Iodine in Presence of Water, as determined by the Measurement of the Electromotive Force of the Zinc-Iodine Cell. By A. P. Laurie, Esq., B.A., B.Sc.

During the spring of 1882 Mr Burton and I communicated some preliminary experiments on a new method of measuring the heats of combination of the metals with the halogens.*

In this paper I propose to show the result of the application of the method to the study of the heats of combination of iodine and zinc in presence of water.

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* *Proceedings of R.S.E.*, 1881–82.

The heats of combination are in each case obtained from the electromotive force of either the zinc-iodine cell, or of the zinc-cuprous iodide cell.

The zinc-iodine cell consists of a zinc rod and a platinum wire dipped in a water solution of iodine and iodide of zinc.

The zinc-cuprous iodide cell consists of a zinc rod, and a copper wire coated with cuprous iodide, dipped in a solution of iodide of zinc.

When a current passes through a given zinc-iodine cell, various changes take place requiring either the production or absorption of heat. In the first place, there is the combination of the zinc and iodine, producing heat; in the second place, there is the solution of the zinc iodide formed, producing heat. On the other hand, the disintegration of the zinc, the decomposition of the iodine molecule, and the removal of the free iodine from its solution in zinc iodide, absorb heat.

If now a series of cells are made up differing only in the strength of the zinc iodide solution, the heat of solution of the zinc iodide formed in the cell during the passage of a current will vary with the strength of the iodide of zinc solution, and that probably in a way familiar to chemists from the behaviour of sulphuric acid when added in larger and larger quantities to water.

On the other hand, the heat of combination of the zinc and iodine, and the heat absorbed in decomposing the iodine molecule and disintegrating the zinc, will probably remain the same. We shall, in fact, find that the infinitely small quantity of zinc iodide dissolved on passing a current has a definite heat of solution determined by the amount of zinc iodide already dissolved in the water contained in the cell.

Further, if a series of cells are made up differing only in the amount of free iodine dissolved in a given iodide of zinc solution, we shall find the heat absorbed in removing the iodine from its solution in zinc iodide diminish as the amount of free iodine present is increased.

It is also probable that the heat of solution of a constant quantity of iodine will vary with variations in the strength of the iodide of zinc.

Having thus stated what takes place in the cell, the question next to be decided is, Whether the heat given out by these reactions correspond exactly with the electromotive force of the cell?

Sir William Thomson, in publishing his formula connecting the electromotive force of a cell with the heat set free by the reactions taking place, assumed that this correspondence existed. Recent experiments have shown, however, that this is not a true assumption in many cases, and Helmholtz has recently treated the subject from a new point of view.*

The following is, as I understand it, the outcome of his work on chemical combination, in so far as it applies to finding the connection between the heats of combination and the electromotive force of the cell.

In general, when an infinitely small current de passes through a cell at a given absolute temperature θ, a certain amount of heat, $d\mathrm{Q}$, must be supplied to or removed from the cell to keep its temperature constant, apart from the heat developed by the electric resistance of the liquid.

If the electromotive force of the cell corresponds exactly to the heat given out by the reaction taking place in the cell, then no heat need be added or removed.

Now the measurement of this cooling or heating of the cell would be difficult in practice, but, applying the second law of thermodynamics, Helmholtz obtains the following formula, showing that a measure of $d\mathrm{Q}$ can be obtained from the variations in electromotive force due to temperature—

$$\theta\frac{dp}{d\theta}de = \mathrm{J}d\mathrm{Q},$$

where dp is the variation in electromotive force due to temperature.

It is necessary, then, in practice to measure the electromotive force of the cell experimented upon at different temperatures and find the variation, if any, of the electromotive force.

In a cell of one volt, electromotive force at 300° ab. temp., a variation of ·0001 volt per deg. cent. would mean a correction of ·03 volt, or 3 per cent. to be applied before determining the heat of combination from the electromotive force.

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* *Die Thermodynamik Chemischer Vorgänger. Wissenschaftliche Abhandlungen*, Von Hermann Helmholtz, Zweiter Band.

The heat of combination can seldom be obtained with much accuracy from books on thermal chemistry, the conditions under which the reactions have been performed in the calorimeter differing considerably from the conditions in the cell.

For example, three numbers are given by Naumann as representing the heat of combination of zinc and iodine in presence of water—

1st, The heat of combination of zinc and iodine in water, 60540 calorics.

2nd, The heat of solution of zinc iodide in water, 11310 calorics.

3rd, The heat of combination of zinc and iodine obtained by subtracting the second from the first, 49230 calorics.

Now the first and second numbers are obviously average results, the zinc iodide formed dissolving in pure water at the beginning of the reaction, but in a strong zinc iodide solution towards the end.

If care has been taken to use the same quantities of water and zinc iodide in both experiments, no doubt the third number represents fairly well the heat of combination of zinc and iodine.

The above criticism applies to Thomson's book, though more details are usually given by him. It is consequently impossible to compare with exactness these numbers with those obtained by measuring the heats of combination in the iodine cell.

In the following experiments on the zinc-iodine and zinc-cuprous iodide cell, I have used Professor Tait's Thomson electrometer to measure the electromotive forces obtained. Alder Wright recommends a high resistance galvanometer for the purpose, which is certainly more delicate, but not more reliable than this particular instrument.

About 50 divisions of the scale correspond to one volt, and it is possible to read to half a division.

As a standard of electromotive force a Daniell cell was used, made up according to the directions given by Alder Wright,* but specially constructed to make diffusion of the two liquids practically impossible. This cell has, according to Wright, an electromotive force of 1·107 volts.

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* *Electrician*, Feb. 18, 1882. In recent papers Wright states the electromotive force of a Dan. cell differing in some details at 1·112 volts.

To check this cell, I used two Latimer Clerk cells, one made up two years ago, the other made up quite recently. Taking Lord Raleigh's recent determination of the electromotive force of this cell (1·454 volts), the three cells agreed with each other within the errors of experiment.

The electrometer was connected to a vocker so constructed that the zero of the instrument, the deflection due to the cell to be measured, and the deflection due to the Daniell cell, could be noted one after the other. This was always done, and the numbers given at the end are always the mean of several readings. The Daniell did not alter at all from week to week.

When very small variations in electromotive force had to be measured, two or three cells were placed in series, and in some cases cells were connected to the electrometer through similarly constructed cells, especially to note the effects of temperature. No correction has been made for the new determination of the B.A. unit, as this affects both the electromotive force and the zinc dissolved by unit current. Consequently the error introduced in calculating from electromotive force to heat of combination is very slight.*

With the above apparatus the following experiments were made :—

1. Experiments to find the effect on the electromotive force of the cell of varying the nature of the zinc.

2. Experiments to find the effect on the electromotive force of the cell of varying the temperature of the cell.

3. Experiments to find the effect of varying the strength of the iodide of zinc solution. For these the cuprous iodide cell was used, as simplifying the changes taking place in the cell.

4. Experiments on varying the strength of the free iodine present.

5. Experiments on varying the strength of the iodide of zinc solution in the iodine cell.

(1) In making measurements with the electrometer, the surface condition of the metals used is evidently of great importance, as so little current is drawn from the cell. If wet zinc is exposed to the air it becomes coated with a film of hydrate, which perceptibly lowers the electromotive force of the cell.

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* See Alder Wright's recent papers in the *Phil. Mag.* for 1885.

I could find no difference between the deflections given by zinc electro-deposited from pure zinc, zinc "free from arsenic," zinc cleaned with sand-paper, zinc corroded by the iodine solution, and zinc with a freshly-broken crystalline surface. Probably, if two or three cells in series had been used, slight differences in electromotive force would have appeared, as is shown by Alder Wright's results with modifications of the Daniell cell.* It is well known that when a crystalline metal is treated with a weak acid the crystalline structure is brought out by the dissolving of the crystals, which have been cut through in smoothing the surface of the metal, and there is, therefore, probably a slight difference of electromotive force between a smooth-filed zinc surface and a broken crystalline zinc surface. This difference, however, is too small to be shown on the electrometer with one cell.

(2) Two iodine cells in series, containing a dilute solution of iodine and of iodide of zinc, were raised from 10° C. to 50° C. No variation of electromotive force could be detected, showing that the electromotive force does not vary ·0001 in 1° C.

Consequently the correction, if any, to be applied before calculating the heat of combination from the electromotive force is less than 2 per cent.

One iodine cell, made up with a saturated solution of iodide of zinc, was raised from 17° C. to 70° C. No variation of electromotive force could be detected.

(3) A series of measurements of the electromotive force of the zinc-cuprous iodide cell, with varying strengths of iodide of zinc, were made. The amount of zinc iodide in each solution used was estimated by determining volumetrically the amount of combined iodine.

The temperature of the room during the experiments varied a little above and below 20° C.

The results of the observations are given in the table (*a*) at the end of the paper.

The lowest number given is that obtained in a saturated zinc iodide solution; the highest is that obtained with only distilled water in the cell.

In every case zinc corroded in iodine solution, and then washed, was used. Some very minute traces of zinc iodide were therefore possibly present in the distilled water, but probably this number should not be taken as being a trustworthy statement of the heat of solution of the first few molecules of iodide of zinc, as the reactions in the cell are very complicated in this case. The next number obtained for a solution of ·003 grms. ZnI_2 in 1 grm. of water is probably safer as a starting-point for a curve.

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* *Phil. Mag.*, Jan. 1885.

Evidently the determination of the heat of solution of the first traces of a salt is difficult even by this method, though a much nearer approximation can be obtained than that possible in the calorimeter.

It was noticed, in the case of the stronger solutions, that on first placing the zinc rod, damp with distilled water, in the solution, the electromotive force of the cell was 2 or 3 per cent. too high, quickly falling to a constant value. This was no doubt due to the temporary dilution of a layer of liquid next the zinc, and the effect disappeared on drying the zinc with filter paper.

On looking at the table, it is noticeable that the electromotive force begins to fall off more rapidly again as the solution approaches concentration. This is possibly due to the more concentrated solution containing, as is well known, an excess of zinc, and being in fact no longer zinc iodide. This part of the table requires, however, further investigation.

(4) The variations in the electromotive force, caused by gradually increasing the amount of free iodine in a cell containing a constant amount of zinc iodide, are given in the table (*b*).

The free iodine present was estimated with standard hyposulphite solution in the usual way.

This table requires no particular remark.

(5) Three determinations of the variation of the electromotive force of the zinc iodine cell were made, due to varying the strength of the iodide of zinc, one in an iodine solution in distilled water, one in a zinc iodide solution of medium strength, and one in a saturated iodide of zinc solution. The results are to be found in the table (*c*).*

If these numbers are subtracted from those obtained for corresponding solutions in the cuprous iodide cell, the numbers obtained show that the curve for the zinc iodine cell is slightly different, rising a little higher for distilled water, and not falling quite so low for saturated iodide of zinc.

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* Very similar results have been obtained for sulphates and chlorides by Alder Wright, *Phil. Mag.*, 1884.

On comparing these numbers with those already mentioned as given by Naumann, we find that the number (expressed in volts) which he gives for the heat of combination of zinc and iodine is 1·085 volts. The electromotive force of an iodine cell with about ·04 grm. of free iodine, in saturated iodide of zinc solution, is 1·082 volts. Naumann gives the heat of solution of zinc iodide in water as ·162 volts. The average number obtained from the curve is ·110 volts. The number given by Naumann is higher, because it does not represent the average heat of solution up to a saturated solution of zinc iodide.

In conclusion, I think these experiments are sufficient to show that we have here a method peculiarly suitable for the determination of the heat of solution of salts, as it is possible to study the behaviour of the salt under any required constant conditions.

For instance, the heat of solution of zinc iodide in water containing other salts in solution could be evidently determined with great accuracy by this method. It seems probable that another advantage of the method is that no heat requires to be absorbed in varying the salt from a solid to a liquid state. I have not found any indication that the heat required for this change, in the case of zinc iodide, is at all considerable.

TABLE (*a*).—*Variations in Electromotive Force caused by varying the Zinc Iodide in solution as measured in the Zinc-Cuprous Iodide Cell.*

Electromotive Force in Volts.	Grms. of ZnI_2 in 1 grm. of Water.
·390	3·870
·419	3·640
·454	2·490
·488	1·860
·545	·537
·607	·236
·637	·118
·656	·059
·696	·029
·771	·003
·894	D.W.

TABLE (*b*).—*Variations in Electromotive Force caused by varying the amount of Iodine dissolved in a solution containing* ·33 *grms. of* ZnI_2 *in* 1 *grm. of water.*

Electromotive Force in Volts.	Grms. of Iodine in 1 c.c.
1·287	·309
1·271	·155
1·271	·077
1·268	·037
1·259	·018
1·238	·005
1·221	·0006

TABLE (*c*).—*Variations in Electromotive Force caused by varying the strength of the Iodide of Zinc in a cell containing* ·014 *grms. of Iodine in* 1 *c.c.*

Electromotive Force in Volts.	Grms. of ZnI_2 in 1 grm. of water.
1·075	3·870
1·303	·118
1·594	D.W.*

On subtracting these from the cuprous iodide members, we get

·686
·667
·719

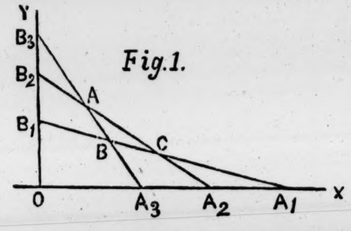
* Iodine calculated to ·014 grams.

8. On Expressions for the Areas of Rectilineal Figures.

By A. H. Anglin, M.A., LL.B., &c.

I. *When the straight lines forming the sides of the figure are referred to two given straight lines at right angles in the plane of the figure*—without reference to the co-ordinates of its angular points.

1. Take OX and OY, two straight lines at right angles to one another in the plane of the figure, as axes of reference; and let the straight lines forming the triangle ABC (fig. 1) meet them in the points A_1, A_2, A_3 and in B_1, B_2, B_3 respectively, the distances from O of the former being in descending, and of the latter in ascending order of magnitude.



With the usual notation, let the equations to the sides of the triangle ABC be

$$y=m_1x+c_1,\ \ y=m_2x+c_2\ \text{ and }\ y=m_3x+c_3.$$

Then, since twice the area of any triangle ABC is

$$\frac{a^2}{\cot \mathrm{B}+\cot \mathrm{C}},$$

we have

$$2\Delta \mathrm{AB_2B_3}=\frac{(\mathrm{B_2B_3})^2}{\cot \mathrm{B}_2+\cot \mathrm{B}_3}=\frac{(c_3-c_2)^2}{m_2-m_3},$$

with similar expressions for the triangles $\mathrm{BB_3B_1}$ and $\mathrm{CB_1B_2}$.

But $$\mathrm{ABC}=\mathrm{AB_3B_2}+\mathrm{CB_1B_2}-\mathrm{BB_1B_3},$$

$$\therefore\ 2\Delta\mathrm{ABC}=\frac{(c_2-c_3)^2}{m_2-m_3}+\frac{(c_3-c_1)^2}{m_3-m_1}+\frac{(c_1-c_2)^2}{m_1-m_2}.$$

Again, by reference to the triangles formed by OX and the sides of ABC produced, since

$$2\Delta\mathrm{AA_2A_3}=\frac{(\mathrm{OA}_2-\mathrm{OA}_3)^2}{\cot \mathrm{A}_2+\cot \mathrm{A}_3}=\frac{(m_2c_3-m_3c_2)^2}{m_2m_3\,(m_2-m_3)},$$

with similar expressions for the triangles $\mathrm{BA_3A_1}$ and $\mathrm{CA_1A_2}$, w have also

$$2\Delta\mathrm{ABC}$$

$$=\frac{(m_2c_3-m_3c_2)^2}{m_2m_3(m_2-m_3)}+\frac{(m_3c_1-m_1c_3)^2}{m_3m_1(m_3-m_1)}+\frac{(m_1c_2-m_2c_1)^2}{m_1m_2(m_1-m_2)}.$$

And each of these expressions for 2ΔABC may be shown to be equal to

$$\frac{\{c_1(m_3-m_2)+c_2(m_1-m_3)+c_3(m_2-m_1)\}^2}{(m_3-m_2)(m_1-m_3)(m_2-m_1)}.$$

We may further observe, that if the equations to the sides of ABC be given in the form $ax+by\ c=0$, the corresponding expressions for twice the area of the triangle are respectively

$$\frac{(b_3c_2-b_2c_3)^2}{b_2b_3(a_3b_2-a_2b_3)}+\frac{(b_1c_3-b_3c_1)^2}{b_3b_1(a_1b_3-a_3b_1)}+\frac{(b_2c_1-b_1c_2)^2}{b_1b_2(a_2b_1-a_1b_2)},$$

and $$\frac{(c_3a_2-c_2a_3)^2}{a_2a_3(a_3b_2-a_2b_3)}+\frac{(c_1a_3-c_3a_1)^2}{a_3a_1(a_1b_3-a_3b_1)}+\frac{(c_2a_1-c_1a_2)^2}{a_1a_2(a_2b_1-a_1b_2)},$$

each of which expressions may be shown to be equal to

$$\frac{\{c_1(a_2b_3 - a_3b_2) + c_2(a_3b_1 - a_1b_3) + c_3(a_1b_2 - a_2b_1\}^2}{(a_2b_3 - a_3b_2)(a_3b_1 - a_1b_3)(a_1b_2 - a_2b_1)}.$$

2. We shall now deduce corresponding expressions for the area of a quadrilateral, and generally for the area of a rectilineal figure of any number of sides.

The triangle ABC is formed by three lines which we call 1, 2, 3. Denoting the area of the triangle formed by any two lines (1, 2) and either axis, by (12), we have seen that

$$\Delta(\mathrm{ABC}) = (12) + (33) + (31),$$

where (12) stands for either

$$\frac{(c_1 - c_2)^2}{2(m_1 - m_2)} \text{ or } \frac{(m_1c_2 - m_2c_1)^2}{2m_1m_2(m_1 - m_2)},$$

with similar expressions for (23) and (31).

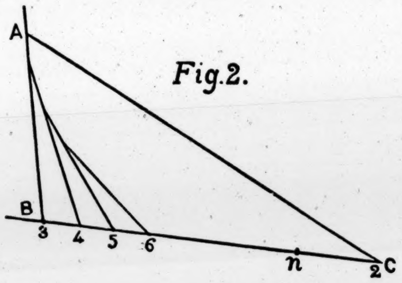


Fig.2.

Now (fig. 2), let a fourth line be drawn cutting the sides 3 and 1 of the triangle, and so intercepting a quadrilateral formed by the lines 1, 2, 3, 4 in order opposite to that of the hands of a clock. Then

$$\begin{aligned}&\text{Area of quadrilateral } (1234)\\ &\quad= \Delta(123 - \Delta(143)\\ &\quad= (12) + (23) + (31) - (14) - (43) - (31)\\ &\quad= (12) + (23) + (34) + (41);\end{aligned}$$

that is, consists of the four triangles formed by either axis, and the lines of the figure taken two at a time in order round the figure from 1 to 1 in the same direction as before stated.

Again, let a fifth line be drawn cutting the sides 4 and 1 of the quadrilateral, and thus intercepting a pentagon formed by the lines 1, 2, 3, 4, 5 in order as before. Then

$$\begin{aligned}&\text{Area of pentagon } (12345)\\ &\quad= \text{quadrilateral } (1234) - \Delta(154)\\ &\quad= (12) + (23) + (34) + (45) + (51),\end{aligned}$$

which consists of the five triangles formed in the same way as above.

So if a hexagon, heptagon, &c., be constructed in like manner, the line drawn necessary to complete any figure always intersecting the last drawn side of the preceding figure and the line 1, we shall have corresponding expressions for the areas of the figures formed in exactly the same way, and consisting of a series of terms denoting the areas of the triangles formed by either axis and the lines 1, 2, 3, 4, &c., taken two at a time in order all round the figure, each line or number occurring twice; so that if the area of a polygon of $n-1$ sides be

$$(12)+(23)+(34)+(45)+\ldots+(n-2,n-1)+(n+1,1),$$

drawing an nth line so as to cut the $(n-1)$th line and the line 1, the area of the polygon of n sides so formed will be equal to

$$\text{Area of polygon of } n-1 \text{ sides} - \Delta(1,\,n,\,n-1),$$

that is,

$$(12)+(23)+(34)+(45)+\ldots+(n-1,\,n)+(n1),$$

in which each number from 1 to n, and so each c and m in the equations to the sides, occurs twice, thus showing the truth of the law for a figure of any number of sides.

As an algebraical result we may note:—We have seen that the sum of three expressions, involving any three suffixes, of which $\frac{(c_1-c_2)^2}{m_1-m_2}$ is a type, is equal to the sum of three expressions involving the same suffixes, of which $\frac{(m_1c_2-m_2c_1)^2}{m_1m_2(m_1-m_2)}$ is a type, each sum being equal to the same expression of the form $\frac{A^2}{B}$. It follows also from the preceding results, that the sums of 4, 5, 6, . . . , n expressions (selected as indicated above), of the first type are equal to the sums of the corresponding number of expressions of the second type, each sum denoting twice the area of the polygon of the corresponding number of sides—the truth of which may also be shown algebraically, and without reference to the areas of figures. For, completing the series of terms in any case by replacing those terms which cancelled, the expression for the area of a figure will consist of a series of three-termed expressions, each of which denotes the area of a triangle, and is of the form $\frac{A^2}{B}$,—the quadrilateral having two such expressions, the pentagon having three, &c., and the figure of n sides having $n-2$; and such an expression, as we have seen, is obtained whether it is composed of terms of the first or second type.

The same remarks will apply to the pair of expressions

$$\frac{(b_1c_2-b_2c_1)^2}{b_1b_2(a_1b_2-a_2b_1)} \text{ and } \frac{(c_1a_2-c_2a_1)^2}{a_1a_2(a_1b_2-a_2b_1)}.$$

II. *When the straight lines forming the sides of the figures are referred to three given intersecting straight lines in the plane of the figure.*

The method employed is uniform with the first method.

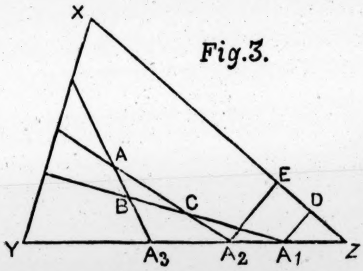


Fig. 3.

1. Let XYZ (fig. 3), the triangle formed by the three given straight lines, be taken as the triangle of reference, the position of any point being determined by its distances (α, β, γ) from the sides.

With the usual notation, let the equations to the sides of the triangle ABC, whose area we seek, be

$$l_1\alpha+m_1\beta+n_1\gamma=0,\quad l_2\alpha+m_2\beta+n_2\gamma=0,\quad l_3\alpha+m_3\beta+n_3\gamma=0,$$

and suppose the sides when produced to meet YZ $(\alpha=0)$ in the points A_1, A_2, A_3. Then

$$\Delta ABC=\Delta AA_2A_3+\Delta CA_1A_2-\Delta BA_1A_3.$$

Now $2\Delta CA_1A_2=A_1A_2\times$ the α of the point C, that is, of the point of intersection of the lines $l_1\alpha+m_1\beta+n_1\gamma=0$ and $l_2\alpha+m_2\beta+n_2\gamma=0$, which is given by

$$\frac{\alpha}{m_1n_2-m_2n_1}=\frac{\beta}{n_1l_2-n_2l_1}=\frac{\gamma}{l_1m_2-l_2m_1}=\frac{2\Delta}{\begin{vmatrix} a, & b, & c\\ l_1, & m_1, & n_1\\ l_2, & m_2, & n_2\end{vmatrix}},$$

Δ denoting the area of the triangle of reference, and a, b, c its sides.

And, A_1D, A_2E being perpendiculars on XZ,

$$A_1A_2 = ZA_2 \mathbin{\dot{-}} ZA_1 = \frac{A_2E - A_1D}{\sin Z}$$

$$= \frac{2\Delta}{\sin Z}\left(\frac{n_2}{bn_2 - cm_2} - \frac{n_1}{bn_1 - cm_1}\right)$$

$$= \frac{abc(m_2n_1 - m_1n_2)}{(bn_1 - cm_1)(bn_2 - cm_2)},$$

since A_1D is the β of the point of intersection of the lines $\alpha = 0$ and $l_1\alpha + m_1\beta + n_1\gamma = 0$, A_2E being obtained in like manner.

Thus
$$\Delta CA_1A_2 = \frac{abc\Delta \times (\quad)(m_1n_2 - m_2n_1)^2}{-\begin{vmatrix} a, & b, & c \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix}(bn_1 - cm_1)(bn_2 - cm_2)},$$

which is the corresponding expression to $\dfrac{(c_1 - c_2)^2}{m_1 - m_2}$ in Case I. Similar expressions holding for the triangles AA_2A_3 and BA_3A_1, we shall get

$$\Delta ABC = (23) + (12) + (31),$$

which may be shown to be equal to the expression

$$\frac{\Delta abc\{l_1(m_2n_3 - m_3n_2) + l_2(m_3n_1 - m_1n_3) + l_3(m_1n_2 - m_2n_1)\}^2}{\begin{vmatrix} a, & b, & c \\ l_2 & m_2 & n_2 \\ l_3 & m_3 & n_3 \end{vmatrix}\begin{vmatrix} a, & b, & c \\ l_3 & m_3 & n_3 \\ l_1 & m_1 & n_1 \end{vmatrix}\begin{vmatrix} a, & b, & c \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix}} \quad (A)$$

We may observe (as possessing an algebraical interest), that by considering in like manner the triangles intercepted by the other sides ZX ($\beta = 0$) and XY ($\gamma = 0$) of the triangle of reference, we shall obtain two other expressions for the area of the triangle ABC in the form $(12) + (23) + (31)$, namely, those in which (12) denotes respectively

$$\frac{k(n_1l_2 - n_2l_1)^2}{(cl_1 - an_1)(cl_2 - an_2)} \quad\text{and}\quad \frac{k(l_1m_2 - l_2m_1)^2}{(am_1 - bl_1)(am_2 - bl_2)},$$

in which k stands for the common factor
$$\frac{\Delta abc}{-\begin{vmatrix} a, & b, & c \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix}},$$

with similar expressions for (23) and (31); and thus the sum of three similar terms involving the same letters, of which *any one* of the above three expressions for (12) is a type, is the same, that sum denoting the area of the triangle ABC and being equal to the expression (A).

Further we may notice that if the sides of the triangle ABC be given by equations of the form $lx+my+nz=0$, where x, y, z denote the *areal* co-ordinates of a point, corresponding results will be obtained by writing la, mb, nc, for l, m, n respectively; or, which comes to the same thing, by putting $a=b=c=1$ in any expression denoting an area.

Thus, in areal co-ordinates, the value of (12) is

$$\frac{\Delta(m_1n_2-m_2n_1)^2}{(m_1-n_1)(m_2-n_2)\begin{vmatrix} l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \\ 1, & 1, & 1 \end{vmatrix}},$$

and the area of triangle ABC is

$$\frac{\Delta\begin{vmatrix} l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \\ l_3 & m_3 & n_3 \end{vmatrix}^2}{\begin{vmatrix} l_2 & m_2 & n_2 \\ l_3 & m_3 & n_3 \\ 1, & 1, & 1 \end{vmatrix}\begin{vmatrix} l_3 & m_3 & n_3 \\ l_1 & m_1 & n_1 \\ 1, & 1, & 1 \end{vmatrix}\begin{vmatrix} l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \\ 1, & 1, & 1 \end{vmatrix}}.$$

2. The area of a quadrilateral, and generally of a figure of n sides, may be deduced in the same manner as in Case I. We thus get, Δ_n denoting the area of a figure of n sides,

$$\Delta_n=(12)+(23)+(34)+(45)+\dots+(n-1,\, n)+(n1),$$

in which (12) denotes any one of the three expressions obtained above as its value, with similar corresponding expressions for the other $n-1$ terms of the series.

And we may notice, as an algebraical result, in addition to that already stated for the case of three expressions, that the sums of 4, 5, 6, . . . , n expressions (selected and having signs as indicated above), of which any one of the above three expressions for (12) is a type, are equal to the sums of the corresponding number of expressions of each of the other types, each sum denoting the area of the polygon of the corresponding number of sides—the truth of which may also be shown, as in Case I., without reference to the areas of figures. For, completing the series of terms in any instance, the expression for the area of a figure will consist of a series of symmetrical expressions similar to (A); and such an expression, as we have seen, is obtained whether it be composed of terms of the first, second, or third type.

III. *When the straight lines forming the sides of the figures are referred to a given point in the plane of the figure.*

1. Let O (fig. 1) be the given point; and suppose, for the present, OX to be a fixed straight line through O. We shall adopt a method uniform with the foregoing methods.

With the usual notation, let the equations to the sides of the triangle ABC be

$$x\cos\alpha_1 + y\sin\alpha_1 - p_1 = 0,\ (\alpha_2, p_2) = 0,\ (\alpha_3, p_3) = 0,$$

where α_1, α_2, α_3 are in descending order of magnitude. Then

$$2\Delta \mathrm{CA}_1\mathrm{A}_2 = \frac{(\mathrm{A}_1\mathrm{A}_2)^2}{\cot \mathrm{A}_1 + \cot \mathrm{A}_2} = \frac{(p_1\sec\alpha_1 - p_2\sec\alpha_2)^2}{\tan\alpha_1 - \tan\alpha_2}$$

$$= \frac{(p_1\cos\alpha_2 - p_2\cos\alpha_1)^2}{\cos\alpha_1\cos\alpha_2\sin(\alpha_1 - \alpha_2)},$$

with similar expressions for the triangles $\mathrm{BA}_3\mathrm{A}_1$ and $\mathrm{AA}_2\mathrm{A}_3$.

Also, by reference to the triangles intercepted by OY, we shall get

$$2\Delta \mathrm{CB}_1\mathrm{B}_2 = \frac{(\mathrm{B}_1\mathrm{B}_2)^2}{\cot \mathrm{B}_1 + \cot \mathrm{B}_2} = \frac{(p_1\operatorname{cosec}\alpha_1 - p_2\operatorname{cosec}\alpha_2)^2}{\cot\alpha_2 - \cot\alpha_1}$$

$$= \frac{(p_1\sin\alpha_2 - p_2\sin\alpha_1)^2}{\sin\alpha_1\sin\alpha_2\sin(\alpha_1 - \alpha_2)},$$

similar expressions holding for the triangles $\mathrm{BB}_3\mathrm{B}_1$ and $\mathrm{AB}_2\mathrm{B}_3$.

Thus, denoting either of the two expressions obtained by (12), we have

$$2\Delta\mathrm{ABC} = (12) - (13) + (23);$$

and each of these expressions for $2\Delta\mathrm{ABC}$ may be shown to be equal to

$$\frac{\{p_1\sin(\alpha_2 - \alpha_3) + p_2\sin(\alpha_3 - \alpha_1) + p_3\sin(\alpha_1 - \alpha_2)\}^2}{\sin(\alpha_2 - \alpha_3)\sin(\alpha_3 - \alpha_1)\sin(\alpha_1 - \alpha_2)}.$$

The corresponding expression for a figure of n sides is

$$(12)+(23)+(34)+(45)+\ldots+(n-1,\, n)+(n1),$$

the terms of which may be of either form of expression above obtained for (12). And, as an algebraical result, it may be shown, as in Case I., that the sum of n expressions in the form of this series is the same, whether the terms of the series be of the form

$$\frac{(p_1 \sec \alpha_1 - p_2 \sec \alpha_2)^2}{\tan \alpha_1 - \tan \alpha_2} \text{ or } \frac{(p_1 \operatorname{cosec} \alpha_1 - p_2 \operatorname{cosec} \alpha_2)^2}{\cot \alpha_2 - \cot \alpha_1}.$$

2. We can now obtain a very interesting form of expression for the area of a figure involving the distances of its sides from the given point, and without reference to the lines OX and OY.

Since $\alpha_2 - \alpha_3$ is the angle between the perpendiculars on the lines 2, 3 it is equal to the angle between the lines themselves, that is the $\angle A$ of the triangle ABC. The expression for $2\Delta ABC$ thus becomes

$$\frac{(p_1 \sin A - p_2 \sin B + p_3 \sin C)^2}{\sin A \sin B \sin C},$$

which may also be appropriately written with $\widehat{23}$, $\widehat{31}$, $\widehat{12}$ for A, B, C respectively.

When the point O is *within* the triangle, the expression for twice its area is $(p_1 \sin A + p_2 \sin B + p_3 \sin C)^2 \div \sin A \sin B \sin C$; and we observe that the necessary change in the sign of p, when the point is outside the figure, is made by the same rule as when the area is given in the form $p_1 a + p_2 b + p_3 c$ (a, b, c being the sides), and can be seen by inspection.

In the case of a quadrilateral we have

$$2 \text{ Area} = (12) + (23) + (34) + (41).$$

Using for (12), &c., the form of expression

$$\frac{(p_1 \operatorname{cosec} \alpha_1 - p_2 \operatorname{cosec} \alpha_2)^2}{\cot \alpha_2 - \cot \alpha_1},$$

expanding and collecting the terms in p^2, we find the expression involving p_1^2 (which consists of the difference of two terms), is

$$\frac{p_1^2 \operatorname{cosec}^2 \alpha_1 (\cot \alpha_4 - \cot \alpha_2)}{(\cot \alpha_2 - \cot \alpha_1)(\cot \alpha_4 - \cot \alpha_1)},$$

that is,

$$\frac{p_1^2 \sin (\alpha_2 - \alpha_4)}{\sin (\alpha_1 - \alpha_2) \sin (\alpha_1 - \alpha_4)},$$

which on completing, so as to have the denominator which is common to all the terms, is

$$\frac{p_1^2 \sin(2, 3, 4)}{\sin(1, 2, 3, 4)},$$

where $\sin(2, 3, 4)$ denotes the product of the sines of $\alpha_2 - \alpha_3$, $\alpha_2 - \alpha_4$, and $\alpha_4 - \alpha_3$, that is, the product of the sines of the angles of the figure formed by the lines 2, 3, 4; while the denominator denotes the product of the sines of the angles of the quadrilateral. Similar expressions holding for the coefficients of p_2^2, p_3^2, and p_4^2, we have

$$2 \text{ Area} = \frac{\Sigma p_1^2 \sin(2, 3, 4)}{\sin(1, 2, 3, 4)} - 2\Sigma \frac{p_1 p_2}{\sin(1, 2)},$$

each summation consisting of 4 terms.

And generally, for a figure of n sides, we shall get in like manner

$$2 \text{ Area} (1, 2, 3, \ldots n)$$

$$= \frac{\Sigma p_1^2 \sin(2, 3, 4, \ldots n)}{\sin(1, 2, 3, 4, \ldots n)} - 2\Sigma \frac{p_1 p_2}{\sin(1, 2)},$$

each summation consisting of n terms, the figure $(2, 3, 4, \ldots n)$ being formed by the sides $3, 4, \ldots n-1$ and the sides 2, n produced.

With regard to the signs of the terms in these series, we observe, in respect of the angles $\alpha_1, \alpha_2, \alpha_3, \ldots \alpha_n$ (see fig. 2), that α_1 is the greatest and α_3 the least; also $\alpha_4, \alpha_5, \ldots \alpha_n$ are in ascending order of magnitude, while α_2 may be $\revangle$ or $\angle$ any of these latter angles. Thus the actual coefficients of $p_3^2, p_4^2, \ldots p_n^2$ are all negative, that of p_2^2 is positive, while the coefficient of p_1^2 is positive or negative according as the last drawn line of any figure makes with BC an angle $\revangle$ or $\angle$C. But the figure $(1, 3, 4, \ldots n)$ has re-entrant angles at the points (4, 5), (5, 6), &c., so that the expression $\sin(1, 3, 4, \ldots n)$, the apparent coefficient of p_2^2, is negative. Also if p_n make with BC an angle $\revangle$C the figure $(2, 3, 4, \ldots n)$ has re-entrant angles at the points (34), (45), &c., so that the expression $\sin(2, 3, 4, \ldots n)$ is also negative. With regard to the signs of the products, they are all positive except those of $p_1 p_2$ and $p_2 p_3$, that is, except those in which p_2 occur.

Hence, the expression for twice the area of figure (1, 2, 3, . . . n) may be written

$$2\Sigma\frac{p_1p_2}{\sin(1, 2)}-\frac{\Sigma p_1{}^2\sin(2, 3, 4, \ldots n)}{\sin(1, 2, 3, 4, \ldots n)},$$

where all the terms in Σp^2 are positive, while all those in the first series are positive except those in $p_1 p_2$ and $p_2 p_3$. In the corresponding expression, when the point O is within the figure, all the signs in both series are positive; and we observe that the necessary change of sign, for an external point, is made according to the rule stated above (in this particular instance by writing $-p_2$ for p_2), the truth of which is evident on inspection of the figure.

3. Lastly, we may deduce the results for *regular* polygons.

Denoting the angle of a regular polygon of n sides by $\pi-\theta$, so that $\theta=\dfrac{2\pi}{n}$, we have

$$\begin{aligned}\sin(2, 3, 4, \ldots n) &= (\sin\theta)^{n-2}\sin 2\theta\\ &= 2\sin^{n-1}\theta\cos\theta.\end{aligned}$$

Thus the expression for the area of the polygon becomes

$$\operatorname{cosec}\theta\,.\,\Sigma p_1p_2-\cot\theta\,.\,\Sigma p_1{}^2,$$

the signs of the terms in each series being the same as before.

If the point O be the centre of the figure, all the p's are equal to one another, each being equal to r the radius of the inscribed circle of the polygon; and thus the area becomes

$$\begin{aligned}&nr^2(\operatorname{cosec}\theta-\cot\theta)\\ &=nr^2\tan\frac{\theta}{2}\\ &=nr^2\tan\frac{\pi}{n},\end{aligned}$$

the usual expression for the area of a regular polygon of n sides in terms of the radius of the inscribed circle.

Note.—In the case of an equilateral triangle and a square, the above expression for area reduces to particular forms: in the former case to $\frac{1}{3}\sqrt{3}(p_1 \pm p_2 + p_3)^2$, and in the latter to $(p_1+p_3)(p_4 \pm p_2)$, according as the point O is within or without the line 2, the truth of which is obvious on inspection of the figures.

9. On Pitchered Insectivorous Plants. Part II. By J. M. Macfarlane, D.Sc.

10. Note on the Salinity of the Tay Estuary and of St Andrews Bay. By Hugh Robert Mill, B.Sc., F.C.S.

In January I read a paper on the salinity of the Firth of Forth,[*] in which the law governing the distribution of salt in that estuary was pointed out. It appeared that in the eastern or seaward part of the Firth the change in mean salinity per mile was very slight, and the tidal range was small, while both decreased gradually as the sea was approached. On the other hand, the riverward half of the Firth showed a rapid alteration in density along its length, and a correspondingly great range between high and low tide.

The estuary of the Tay is shorter, narrower, and shallower than that of the Forth, and the river is much larger, of great volume, and more rapid. It might then be expected that the condition of the seaward part of the Firth of Tay would resemble that of the riverward portion of the Forth in its main characteristics, while the sea around the mouth of the estuary would be perceptibly freshened.

A slight dip in the salinity curve at the Isle of May was referred to in the paper cited above,[†] and the suggestion was thrown out that this might be due to the diluting action of the fresh water of the Tay. This hypothesis has been confirmed by observations made during the first week of June 1885.

The Scottish Marine Station's yacht "Medusa" went from Granton to the Tay on June 2nd, when water samples were collected at regular intervals both from the surface and the bottom. These were afterwards examined, the density determined as described previously,[‡] and reduced to 15°·56 C. to admit of comparison with other observations. The result of this day's work is shown in Table I.

TABLE I.

Position,	Off Inchkeith.	Off Elie.	Off Crail.	St Andrews Bay.	Tay Fairway Buoy.
Tide,	1½ hr. ebb.	4 hrs. ebb.	l. w.	1 hr. fld.	1¾ hr. flood.
Surface density,	1·02488	1·02547	1·02537	1·02505	1·02435

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[*] *Proc. Roy. Soc. Edin.*, xiii. pp. 29–64.

[†] *Ibid.*, p. 53.

[‡] *Ibid.*, p. 35.

TABLE I.—*continued.*

Position,	Tay Lightship.	Lady Buoy.	Off Tayport.		Off Dundee.
Tide,	1¾ hr. flood	2 hrs. fld.	2½ hrs. fld.	5½ hrs. fld.	h. w.
Surface density,	1·01991	1·01760	1·01282	1·01734	1·01394
Bottom density,	1·02381 (10 fm.)	...	...	...	1·01457

This indicates the increase of salinity from Inchkeith to off Elie, and then its increasingly rapid decrease to the mouth of the Firth of Forth, across St Andrews Bay, and up the Tay as far as Dundee. The tide being on the ebb to Crail, increases the apparent rate of freshening very slightly, while its flowing reduces it to a greater degree in the latter part of the journey.

While returning from the Tay to Anstruther, the following series of observations was obtained (Table II.). The course was out of the river and eastward until about 7 miles beyond the Fairway Buoy; S.W. until the North Carr Rock at the entrance to the Firth of Forth was sighted about 1½ mile off, then northwards near the shore until close on Abertay Sands, and finally southward, keeping about a mile off shore until arrival at Anstruther. All this area was freshened more or less by the Tay, taking as a standard of average salinity the usual state of the water between St Abb's Head and the Isle of May. Off St Andrews the water was slightly salter at low than at high tide, a fact which may be accounted for by the drying of the Abertay sandbanks, about half ebb, leading the brackish flow of the river further east than at high tide.

TABLE II.

Position,	Tayport.	Lady Buoy.	Abertay Lightship.	Fairway Buoy.	7 miles E. of Fairway.
Tide,	1½ hr. fld.	2 hrs. fld.	2¾ hrs. fld.	3 hrs. fld.	4 hrs. fld.
Surface density,	1·02184	1·02325	1·02379	1·02424	1·02486
Bottom density,	...	...	1·02514	...	1·02543

Position,	1½ mile N.E. of N. Carr.	Bet. N. Carr and Kingsbarns.	1½ mile off St Andrews.	S. end of Abertay Sands.
Tide,	5 hrs. flood.	h. w.	1 hr. ebb.	1¾ hr. ebb.
Surface density,	1·02491	1·02468	1·02490	1·02468
Bottom density,	...	...	1·02516	1·02511

Position,	Off St Andrews.	Off Kingsbarns.	Off N. Carr.	Off Anstruther.
Tide,	4½ hrs. ebb.	5½ hrs. ebb.	l. w.	1 hr. fld.
Surface density,	1·02510	1·02484	1·02512	1·02539

These observations, while insufficient to trace out the form of the brackish area beyond the mouth of the Firth of Tay, show that St Andrews Bay is affected with the fresher water, and that the Firth of Forth to a few miles west of the May Island is also slightly freshened. Both these effects must be subject to variations from the direction of the wind and the amount of flood in the river. Until further examination is made, speculation on the subject of the general variation of salinity along the coast had better be postponed; but it is certain that if such work could be carried out valuable results would be obtained.

The following are the densities of the water samples collected in the estuary of the Tay (Table III.):—

TABLE III.

Position,	Perth	Newburgh.	
Date,	May 27	May 26	May 26
Tide,	h. w.	h. w.	l. w
Depth,	2 fm.	2 fm.	...
Surface density,	...	0·99931	0·99910
Bottom density,	0·99920	0·99934	...

Position,	The Kirk (5 miles below Newburgh.				Bet. Birkhall Bank and Tay Bridge.
Date,	May 26	May 26	June 3	June 3	June 3
Tide,	2½ hrs. ebb.	1½ hr. fld.	3½ hrs. fld.	h. w.	2 hours fld.
Depth,	3 fm.	5 fm.	3½ fm.	...	4¾ fm.
Surface density,	1·00491	0·99910	1·00140	1·00286	1·00395
Bottom density,	1·00807	0·99940	1·00122	...	1·00492

Position,	Off Dundee.					
Date,	May 26	May 26	June 2	June 3	June 3	June 3
Tide,	4 hrs. ebb.	l. w.	h. w.	4½ hrs. ebb.	1½ hr. fld.	1 hr. ebb.
Depth,	...	3 fm.	...	...	4 fm.	...
Surface density,	1·00874	1·00413	1·01394	1·01358	1·00909	1·01500
Bottom density,	...	1·00413	1·01457,	...	...	...

Position,	Off Tayport.				
Date,	June 2	June 2	June 3	June 3	June 4
Tide,	2½ hrs. fld.	5½ hrs. fld.	5 hrs. ebb.	1 hr. fld.	1½ hr. fld.
Depth,	...	...	9 fm.	...	...
Surface density,	1·01282	1·01734	1·01459	1·01813	1·02184
Bottom density,	...	...	...	...	...

Position,	Abertay Lightship.		
Date,	June 2	June 3	June 4
Tide,	1¾ hr. fld.	l. w.	2¾ hrs. fld.
Depth,	9 fm.	6 fm.	10 fm.
Surface density,	1·01991	1·01919	1·02379
Bottom density,	1·02381	1·02183	1·02514

This table shows that, as on the Forth, but in a more pronounced manner, the effects of tide and of flooding in the river are very considerable in the upper part of the estuary; so much so that the observations recorded above are of almost no use in determining the normal salinity of the Firth of Tay at any point. The serial densities observed on each day when plotted in a curve, show a state of matters very similar to that existing in the Forth. From Newburgh to the Abertay Lightship corresponds in regard to surface salinity with the stretch of the Forth from Alloa to Queensferry, but the closer proximity to the open sea produces its effect in raising the salinity of the bottom water about the mouth of the Tay.

It appears that in the Tay, while the salt sea water runs up along the bottom so as to produce a very marked difference in the density of the bottom and surface water at the Lightship, it is rapidly mixed as it passes on, no doubt on account of the shallowness of the channel and the strength of the current.

The position of the highest point to which brackish water extends in the Tay at high water is effected by the amount of tidal rise and of flooding in the river. In summer it is said to be always undrinkable at high water at Newburgh; while some fishermen say that the salt can be tasted at Perth during very dry summer weather and at high spring tides.

Although not connected with the salinity, the colour of the water when looked down into on a clear day may be noted. At Newburgh it is a clear amber-brown, which lower down becomes a little muddy, and as the salt manifests itself a green tint is added, so that at Tayport it is an exquisite olive-green, a colour which prevails with a lessening of the brown ingredient right across St Andrews Bay. This contrasts with the pale muddy green of the upper reaches of the Firth of Forth, which gives place to a deeper and more transparent blue-green tint as the Isle of May is approached. The effect is very much that which would be produced if a green liquid (*e.g.*, solution of dark transparent cupric chloride) were diluted gradually with water for the Forth, and with a brownish-yellow liquid (*e.g.*, very dilute ferric chloride solution) for the Tay.

11. Concluding Address by David Milne Home, Vice-President.

At this, the concluding meeting of the Session, some observations and information are expected from the Chairman for the night, and which I now, at the request of the Council, proceed to offer.

During the past Session there have been sixteen ordinary meetings of the Society for the reading of papers, which may be classed under the following heads:—22 in Natural Philosophy, 11 in Chemistry, 10 in Mathematics, 7 in Physiology, 6 in Meteorology, 4 in Zoology, 3 in Mineralogy, 3 in Geology, 1 in Anthropology, 1 in Astronomy, and 1 in Mechanics.

The total number of papers is 72, being two more than the average of the last two years.

It will be observed, that all these papers are on branches of *Physical Science.* There have been none of a *literary character*—though literature is one of the objects which our Society was intended to encourage—and though Lord Moncreiff, till lately our President, has more than once, from this Chair, expressed a wish and a hope that there would be contributions to our meetings under that head also.

But this object, I fear, it is difficult to accomplish. The discoveries and speculations of a scientific nature are now so important and so urgent, that they crowd in upon every Society which will admit them; whilst, on the other hand, speculations in mental philosophy come before the public more readily, and perhaps more suitably, through the columns of innumerable magazines, journals, reviews, and newspapers, published monthly, weekly, or daily.

I see from looking at some of the addresses delivered from this Chair at the close of a Session, that it has occasionally been the practice to express an opinion regarding the merits of the papers read. I shrink from following that practice, first, because of not having heard any of the papers; and, more particularly, because I frankly avow my incompetence to form an opinion on three-fourths of the papers, judging from their titles. But in our Society there is some guarantee that any papers by Fellows of our Society shall not be unworthy of it, because we admit no person to become a

Fellow who is not recommended and vouched for by trustworthy persons, as having a taste for and a knowledge of either scientific or literary subjects; and having been myself on many occasions a member of Council, before which applications for admission come, I know that this rule is honestly acted on.

I do not find that this rule keeps back any whom we would desire to welcome within our walls. During the past Session the number of Fellows admitted was twenty-five, whereas the average number during the four previous years was twenty.

I am sorry to say, however, that during the past year an unusual number of deaths among our members has occurred—one in the Honorary class, thirteen in the Ordinary class.

The *Honorary* Fellow deceased was *Professor von Siebold*, who died last spring at the age of eighty-one. For the last thirty years of his life he was Professor of Zoology and Comparative Anatomy in the University of Munich. He is said to have written altogether 130 scientific papers, several of which were so appreciated in this country, that they were translated into English by Professor Huxley and Mr Dallas. *Von Siebold* was a corresponding member of the French Institute, and a honorary member of the Royal Society of London.

Of the deceased Fellows in our *Ordinary* class, the first name to be mentioned is that of *Sir Alexander Grant*, the distinguished Principal of Edinburgh University, who died on 1st December 1884. He was the representative of a branch of the Seafield family, and inherited a baronetcy which had been conferred in the year 1688.

Though eminently qualified to take part in the business of our Society, especially in the department of literature, Sir Alexander Grant's other important duties too much engrossed his attention, to allow him to do more than deliver an address at the commencement of one of our Sessions, and to give several obituary notices.

At Oxford University, as a student, he distinguished himself by his attainments in classics, philosophy, and general literature, and whilst resident there, he brought out the edition of Aristotle's Ethics, with English notes, which at once stamped him as an eminent scholar and a man of intellectual power. His first appointment to a post of duty was that of Inspector of Schools at Madras. A few years afterwards he was elected to the higher position of Professor of History in Elphinstone College. Subsequently he was promoted to be Vice-Chancellor of Elgin College, Bombay, which last position he held for four years, till 1868, when he was chosen to be Principal of Edinburgh University.

In all these positions Sir Alexander threw himself earnestly and enthusiastically into the work which these positions implied, and at the same time by his genial spirit he gained the hearty co-operation of all with whom he came in contact. To the academic interests of the students of our University he especially devoted himself, not only by opening almost every winter session with an address full of encouragement and good advice, but by aiding them in organising for themselves a Representative Council and a Students' Union.

The immense efforts made by Sir Alexander Grant during the last year of his life, to celebrate suitably the Tercentenary of our University, were probably the cause of the failure of health which supervened when these labours were over. The compilation and publication during the previous winter of two volumes on the History of the University; the arrangements for bringing to Edinburgh in the spring of 1884, from all parts of the world, men of academic renown, and the organisation necessary for providing suitable hospitality to these distinguished strangers; whilst these things acted as a stimulus at the time, they left Sir Alexander, when the celebration was over, in a state of prostration, from which, notwithstanding a holiday taken during the summer in Derbyshire, he never recovered.

I might say much more, especially in reference to what our distinguished associate did for the extension of our University Buildings. But this is not the opportunity, nor am I the person, to enlarge on this subject. I have no doubt there will be laid before us, by some one of our number (who knows better than I do his character, and his deeds of usefulness), a fuller and better biographical account than I can venture on.

It was only a becoming tribute of general esteem and respect, that the civic authorities of Edinburgh resolved that there should be a public funeral. It was attended not only by all the professors and students of our University, but by representatives from every scientific and literary society in Edinburgh.

The next deceased Fellow whose name I mention, is the *Rev.*

Dr Lindsay Alexander. He died at his residence in the parish of Inveresk on 20th December 1884.

He was for a time one of our Vice-Presidents; and he frequently attended our meetings, and took an interest in our discussions. But I am not aware that he contributed any paper beyond an address at the opening of one of our Sessions, and several obituary notices.

Born in Leith, and obtaining his earliest education at our High School, he subsequently went to St Andrews University to attend Dr Chalmers' Lectures on Moral Philosophy. At the early age of nineteen he became Professor of Classics and Mathematics in one of the Theological Training Colleges of the English Congregationalists. After holding that position for four years, he occupied in Liverpool a chapel as a lay preacher; and he thereafter resolved to follow that profession for life.

With that view he went to Germany to attend theological lectures, and on his return to Edinburgh received an appointment as minister of the Independent Congregation then meeting in Argyll Square; after which he became minister of the handsome building in George IV. Bridge, called the Church of St Augustine, erected at a cost of £15,000, and where he continued for about twenty years, till he resigned from failing health.

He was deeply reverenced by the members of his congregation, and much respected by persons of other denominations, who frequently went to listen to his discourses; two of whom were, I know, Dean Ramsay and his brother Admiral Ramsay, who were always with him on terms of social intercourse.

Dr Lindsay Alexander was a man of a tolerant and liberal spirit. I remember when, some years ago, it was proposed to give a testimonial to the Rev. Mr Beveridge, the parish minister of Inveresk, on his completing the fiftieth year of his ministry there, Dr Alexander not only joined in the subscription, but went to the public meeting where the testimonial was presented, and spoke in commendation of Mr Beveridge.

Dr Lindsay Alexander was distinguished for his scholastic knowledge. His acquaintance with theological works was so great, that he was appointed to the Theological Hall of the Congregational body, first as Professor of Systematic Theology, and afterwards as

Principal of the College. He was also a member of the committee for revising the authorised version of the Old Testament.

He published several treatises, chiefly theological. He contributed articles to the eighth edition of the *Encyclopædia Britannica* on "Moral Philosophy" and "Scripture Theology." The collection of hymns now used in the Augustine Church was entirely composed by him.

In these circumstances, it was natural that Dr Alexander should receive many public testimonials of the esteem in which he was held. In February 1876, on the completion of the fortieth year of his ministry, the congregation of his church presented to him an address, from which I quote these words, "to express their grateful recognition of his profound learning, and of the fearless fidelity and true Christian love with which he had discharged the duties of his sacred office." Since his death, as I see from to-day's newspapers, a marble bust was placed last Saturday in the corridor of Augustine Chapel, bearing Dr Lindsay Alexander's name, as "the honoured minister of this Church for forty-three years; eminent as a theologian, preacher, and scholar."

Professor Fleeming Jenkin, who died suddenly only a few weeks ago, was Professor of Engineering in Edinburgh University, being the first who occupied that chair. He was skilled in various branches of engineering, especially in electricity with reference to its mechanical applications. For several years he worked in connection with Sir William Thomson of Glasgow University in the manufacture and laying down of several great submarine telegraph lines. During the last two years of his life he is said to have occupied himself in endeavouring to invent a system of electrical locomotion, to which he proposed to give the name of "*Telpherage*."

In the year 1877 he gave two lectures before the Edinburgh Philosophical Institution on "Sanitary Houses," which created so much interest that they led to the formation of the Edinburgh Sanitary Protection Association, the first of its kind, and the usefulness of which has been so generally acknowledged that it has led to the formation of similar associations elsewhere.

Professor Jenkin was the author of numerous important papers, which appeared in magazines and reviews—one on Magnetism and Electricity (published in 1883), so much appreciated that it was translated into German and Italian.

Professor Jenkin began his education at a school in Jedburgh, from which he passed to the Edinburgh Academy. Subsequently he visited Germany, France, and Italy, staying in each country long enough to master the language. He took his M.A. degree at Genoa University, after which he proceeded to Marseilles, where he began the practical work of life in the employment of a Locomotive Steam-engine Company. Thereafter he returned to England, and, becoming an associate of the Institute of Civil Engineers, soon advanced into more extended and profitable employment.

Thomas C. Archer, Director of the Museum of Science and Art, died on 17th February last, very suddenly, in a hotel in London, whilst speaking to his daughter, though then apparently in his usual health.

He had been in charge of our Museum since the year 1860, having been appointed on the death of Professor George Wilson, who was then Director of that Institution.

Mr Archer directed his whole time and thought to the procuring of objects of interest for the Museum, not only by purchases at the expense of Government, but even by occasionally obtaining temporary loans for exhibition of valuable objects from individuals to whom they belonged.

He went frequently to the Continent in search of specimens, and in 1876 he was sent as Joint British Commissioner to the Philadelphia Exhibition of Arts and Industry. He had great business tact, and, in particular, never omitted any favourable opportunity of pressing the Government for additional grants to extend or enlarge the buildings, to accommodate the stores he collected, and of which he generally contrived to show a supply in boxes unpacked, to prove the necessity of more space for his treasures.

I am not aware that he ever took any part in the business of our Society.

Professor Morrison Watson, who died on the 25th March last, at the early age of thirty-nine, began his short life of usefulness by receiving his educational training in Edinburgh. He took a degree in our University as Doctor of Medicine, receiving for his thesis a gold medal. He became Fellow of the Royal College of Physicians, a Fellow of our Royal Society, and subsequently a Fellow of the Zoological Society of London. For some years he was Demonstrator of Anatomy in Edinburgh University, under Professor Goodsir and Professor Turner. In 1874, on the amalgamation of the Manchester Medical School and Owens College, he was elected there Professor of Anatomy. Whilst holding that appointment he wrote valuable papers on zoological subjects, the last being an elaborate memoir of above 200 quarto pages on the *Penguin*, from notes taken during the voyage of the "Challenger."

Professor Morrison Watson's career of usefulness was cut short in a strikingly impressive manner. Whilst delivering a lecture to his students he suddenly became speechless and unconscious, owing, as was afterwards discovered, to the rupture of a blood-vessel in the head. So precarious was his condition, that for three weeks he could not be moved from the college. He was then carried to a convalescent hospital adjoining the college, but he survived there only a few days.

General Sir James Alexander, K.C.B., of Westerton (Stirlingshire), who died a few weeks ago, occasionally attended our meetings, but I am not aware that he contributed any papers.

As an officer in a Scotch regiment, he saw much active service in foreign lands, viz., New Zealand, at the Cape of Good Hope, and also in Egypt.

When in Egypt, he became interested in the great buildings and obelisks of antiquity; and when he returned home, endeavoured to bring about some arrangement for transporting to this country Cleopatra's Needle. Having heard that the late Captain Donaldson Boswell, R.N., of Wardie, had entertained the same idea, and had submitted to the Admiralty a report showing how the transport of the obelisk might be accomplished, Sir James applied to me to assist him in procuring access to these plans, my brother, Sir Alexander Milne, being then at the Admiralty. These plans having been obtained, Sir James went with them back to Egypt, and satisfied himself of the possibility of removing the prostrate obelisk. Having received from the Khedive permission to construct a huge box, to contain and float the obelisk, he returned to England, and applied first to the Admiralty, and then to the Treasury, for the necessary funds, which he estimated would amount to £10,000. His applications in these quarters having been peremptorily refused, he next appealed to a wealthy personal friend, Dr Erasmus Wilson of London, who eventually agreed to give the money. Sir James then went back to Egypt to superintend the removal, which was entirely successful, notwithstanding that in the course of the voyage, a heavy gale having come on, the cable which dragged the barge containing the obelisk broke, and there was much difficulty in recovering it. It finally reached the Thames, and the obelisk now stands on the Thames Embankment.

Another object of public interest which next occupied Sir James was a fortification with heavy guns to be erected on Inchkeith, for the protection of Leith and Edinburgh against enemy's ships. He was at great trouble to get petitions from the Magistrates of Edinburgh and Leith, and from the towns on the shores of the Firth of Forth, to the Government, urging the erection of these defences. He at length succeeded, and had the pleasure of seeing the fortifications erected and mounted with guns.

He next engaged in endeavouring to procure a similar protection for Greenock and Glasgow, by fortifications at the entrance of the Firth of Clyde. He did not live long enough to see the erection of these fortifications, but before he died he knew that his proposal had been adopted by Government, and that it only remained to fix on the spot where the fortification should be erected.

Out of respect for the memory of an old personal friend, and a Fellow of our Society, I have thought it right to mention these details regarding Sir James Alexander, as a tribute due to one who did useful work for his country at home, after serving his country as a brave soldier abroad.

These obituary notices of life and work apply to only six of the thirteen Fellows who have died during the past year. Had there been more time for inquiry, perhaps others might have been found also deserving some special notice.

But even from those few to whom I have been enabled to refer, on account of their services to science and to the public interests, may I not venture to infer that the prestige of our Society has not deteriorated, and that, as the past year has shown an unusual accession of new members and a greater amount of business, we may hope for a continuance of prosperity and usefulness?

APPENDIX.

1. Demonstration of Theorems A, B, C, &c., page 484 of *Transactions*, Royal Society of Edinburgh, vol. xxxii. By Rev. T. P. Kirkman, M.A., F.R.S.

1. In the circle of an unifilar knot every crossing a is read twice, once in an odd and once in an even place; and the thread is supposed to pass under and over itself alternately at successive crossings

Every contiguous duad of the circle is a different edge of the knot. Let every mid-edge round the circle be dotted on the right.

Let $$128\ldots a213\ldots 5, \quad . \quad . \quad . \qquad \text{(A)}$$

of $2n$ terms 1, 2, &c., where 51 is a contiguous duad, be the circle of an unifilar $_n$N of n crossings. We see that 1 and 2 are the crossings of a 2-gon; for no mesh of $_n$N but a 2-gon can have two summits joined by two different edges of the mesh. (A) is the circle of any unifilar which has the duads 12 and 21.

Let us write the above thus, omitting only the crossing 1, and simply reversing one of the sequences between 1 and 1—

$$28\ldots a25\ldots 3, \quad . \quad . \quad . \qquad \text{(B)}$$

where 32 is a contiguous duad. What does this mean, when in the projection of $_n$N the 2-gon is shrunk up to a point 2, the edges 12 and 21 disappearing?

It is the circle of an unifilar $_{n-1}$M of $n-1$ crossings, which has every duad of (A) except 12 and 21; for it has 51 and 13 because it has 52 and 23, 2 and 1 being now the same point.

2. In (A) as we walk from 1 to 2, and later from 2 to 1, we make the circuit of the 2-gon 12 in the same direction round it; therefore our two dots will be both inside or both outside of it. This 12 is an *even* 2-gon; and every even 2-gon mn of an unifilar is known by a glance at the circle, by its exhibition of mn and nm.

3. We have demonstrated the following

Theorem A.—Every unifilar knot $_n$N of n crossings, which has an even 2-gon, can be reduced to an unifilar ${}_{n-1}$M of $n-1$ crossings by shrinking up that 2-gon to a point.

4. Let the sequence of $2n$ terms

$$128 \ldots a123 \ldots 5 \quad . \quad . \qquad \text{(C)}$$

be the circle of an unifilar ${}_n$P of n crossings.

This ${}_n$P has an *odd* 2-gon 12; for since we pass over both its threads from 1 to 2, it must have one dot within and one without it. Any unifilar that has an odd 2-gon is represented by (C). We now write this, omitting the duads 12 and no other, and simply reversing 3 . . . 5—one sequence between 2 and 1;

$$28 \ldots a15 \ldots 3 \quad . \quad . \quad . \qquad \text{(D)}.$$

What means this, when from the projection of ${}_n$P we have deleted the two edges, and consequently the two crossings of the 2-gon 12?

5. The edges of the crossings 1 and 2 in (C) are 12, 1a, 12, 15 and 21, 28, 21, 23. These make angles 212 and 51a vertically opposite, and 121 and 823 vertically opposite, where 51a and 823 are angles of the $(4+r)$-gon F′ laid bare by deletion of the 2-gon 12. The points 1 and 2 of these angles are merely bends or creases at the mid-points of the edges 5a and 83 of the $(2+r)$-gon F. Effacing the creases 1 and 2, (D) becomes

$$8 \ldots a5 \ldots 3, \quad . \quad . \quad . \qquad \text{(E)};$$

which contains every crossing of (C) but 1 and 2, and every duad of (C) except 12, 1a, 15, 23, 28, and has besides the new edges 83 and 5a of the $(2+r)$-gon F. This (E) is the circle of an unifilar ${}_{n-2}$Q of $n-2$ crossings. We have thus proved

Theorem B.—If any unifilar knot ${}_n$P of n crossings has an odd 2-gon, the knot is reduced to an unifilar ${}_{n-2}$Q of $n-2$ crossings by the deletion of the two edges, and consequently of the two crossings of that 2-gon.

6. Let

$$\begin{array}{l} \ldots d765r \ldots p567s \\ \ldots d765r \ldots p765s \quad . \quad . \quad . \qquad \text{(F)} \end{array}$$

be two circles of two unifilars of n crossings. In both of them 56 and 67 are contiguous 2-gons, having a common crossing 6—that is, both knots have a double 2-gon (a plural flap) 567. Let the first 7 in each be in an even place; then the second 7 is in an odd place, art. 1. Let the thread cross over itself in the even places. In both circles (F) then the thread, passing under itself at d, 6, and r, goes onwards till it passes over itself at p, 6, and s, proceeding till it comes under itself again at d. Let now the double flap 765 in the projection of each circle be shrunk to a point 7, the four edges of its two 2-gonal loops 65 and 67 disappearing. These circles thus become the two unifilars of $n-2$ crossings,

$$\begin{array}{l} \ldots d7r \ldots p7s \ldots \\ \ldots d7r \ldots p7s \ldots \qquad . \qquad . \qquad \text{(G)}, \end{array}$$

which of course differ exactly as do the circles (F) in the portions omitted. The thread in each goes under at d, over at 7, under at r, and so on its course till it passes over at p, under at 7, over at s . . . and finally comes again under at d, as before the shrinking. And this is true whatever be the crossings d, r, p, s, in 2-gons or not, and whether these four be or not crossings in like meshes on the knots. Thus is proved

Theorem C.—If any unifilar knot ${}_n\mathrm{R}$ of n crossings has a double flap, the two contiguous terminal 2-gons of a $(2+i)$-ple flap, $(i \overset{=}{>} 0)$, it is reduced, by the shrinking up of the two 2-gons to a point, to an unifilar S of $n-2$ crossings.

7. Returning to the even 2-gon 12 of art. 1, it is plain that at its crossings it is covertical with two meshes whose edges, meeting at 1 and at 2, will be dotted both of each pair inside or outside its mesh, according as the 2-gon 12 has its dots both outside or both inside of it. And it is equally plain that every crossing r of a knot has two covertical angles about it so evenly dotted, and another covertical pair which have both one, and only one, dot inside those angles about r. We may call the latter pair the *odd* angles, and the former the *even* angles about r.

In the unifilar ${}_{n-1}\mathrm{M}$ whose circle is (B), art. 1, we can reverse the process by which ${}_{n-1}\mathrm{M}$ is obtained from ${}_n\mathrm{N}$, *i.e.*, we can, by restoring in the projection of ${}_{n-1}\mathrm{M}$ the deleted 2-gon 12, construct upon it ${}_n\mathrm{N}$. In the circle (A) $a28$ and 315 are even angles about the crossings 2 and 1. In (B), the circle of ${}_{n-1}\mathrm{M}$, we read along 32 and next along 28, dotting both on the right, and later along $a2$ and 25, dotting both on the right; *i.e.*, $a28$ and 325 are even coverticals about 2.

By making these two covertical with a 2-gon we construct ${}_{n}N$, whose circle is (A), and thus demonstrate

Theorem AA.—If at any crossing r of an unifilar knot of $n-1$ crossings we make the two even angles of r covertical with a 2-gon, thus adding an edge to each collateral of the 2-gon, we construct an unifilar of n crossings by one of its even 2-gons.

This is the constructing converse of the Theorem A, art. 3.

8. Let

$$v\ldots fcdr\ldots bam\,..\,s$$

be the circle of an unifilar of k crossings, in which cd and ba are edges of the mesh H, both dotted inside H at their mid-points α in cd and β in ba. The circle is read

$$v\,..\,fc(\alpha)dr\ldots b(\beta)am\,..\,s,$$

say from c above to d below with the dot (α) on the right in H, till we come to the crossing b, and proceed from b below to a above past the dot (β) on the right in the same H. In H draw the 2-gon pq from p between (α) and d to q between b and (β). We now read from c above, not to d but to p below, having the dot (α) on our right in H; then crossing the upper edge pq of the 2-gon, we proceed along the lower pq to q, planting a dot (ϵ) inside the 2-gon on that pq; at q, again crossing the upper pq, we proceed to a past (β) on our right in H, next to m, &c., completing the smaller circle

$$v\ldots fcpqam\ldots s,$$

which contains neither the upper edge of the 2-gon pq, nor any of the crossings $dr\ldots b$. We have constructed a bifilar knot of $k+2$ crossings, and demonstrated

Theorem D.—If in any mesh H of an unifilar knot ${}_{n}T$ we connect by a 2-gon two mid-edges that are dotted either both inside or both outside of H, we complete a bifilar ${}_{n+2}U$.

Observe that the dotting of art. 1 may be done either on the right or on the left of every edge.

9. If in the unifilar ${}_{n-2}Q$ of art. 5 we replace in the $(2+r)$-gonal face F the 2-gon 12 effaced from ${}_{n}P$, art. 4, we reconstruct the unifilar ${}_{n}P$. It follows that of the mid-points 1 and 2 of that face F on ${}_{n-2}Q$ one, and only one, is dotted inside F. For if otherwise

we should construct (Theo. D) by the 2-gon 12, not ${}_nP$ unifilar, but a bifilar ${}_nU$. Thus we have proof of

Theorem BB.—If in the projection of any $(2+r)$-gonal mesh F of an unifilar of $n-2$ crossings we connect by a 2-gon the midpoints of two edges of which one, and only one, is dotted (art. 2) inside F, we construct an unifilar of n crossings by one of its odd 2-gons.

This is the constructing converse of Theorem B, art. 5, and is true when $r \geqq 0$.

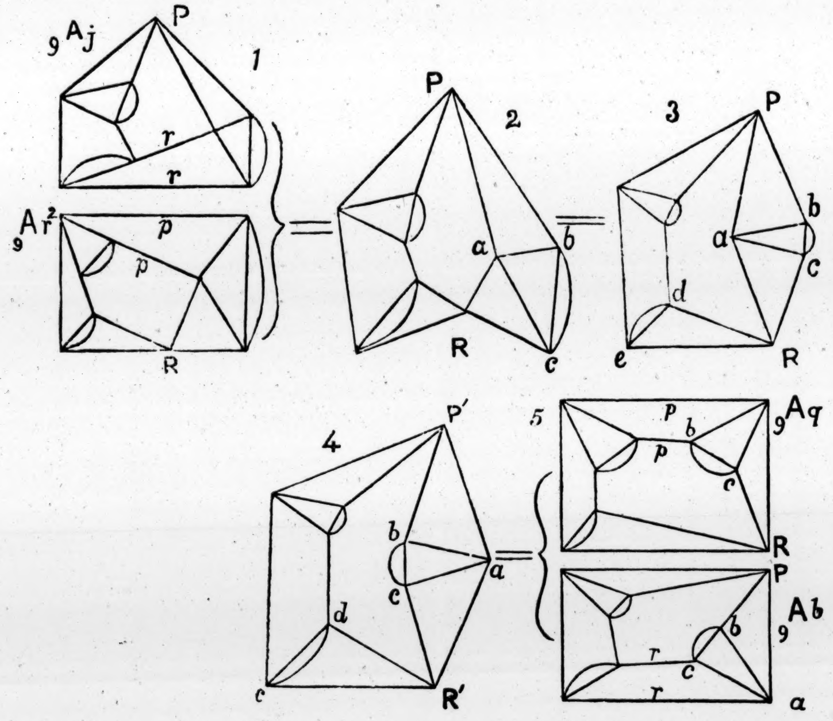
10. The constructing converse of Theorem C is

Theorem CC.—If in any unifilar knot of $n-2$ crossings we make, at any projected crossing r, either pair of opposed angles covertical with a double flap, adding two edges to each of the other pair of opposed meshes about r, we construct an unifilar of n crossings by one of its plural flaps.

No base which has a plural flap, not fixed, can be operated upon by Theorem AA or BB, unless the operation abolishes the plural flap. And every flap, single or plural, is fixed, if its deletion lays bare a section through two edges only. Such a fixed flap cannot compete for the lead, nor hinder an operation by AA or BB, which does not abolish the fixture. Every construction is by a leading flap (*vide* my paper, xvii.), and the leader has the most 2-gons.

2. On the Twists of Listing and Tait. By the Rev. Thomas P. Kirkman, M.A., F.R.S.

In the figure 1 following, the knot ${}_9Aj$ has a triangular section P*rr* cutting away on each side of it a $(3+r)$-gonal mesh, and ${}_9Ar^2$ has such a section R*pp*, through one crossing only. Make in these knots creases at *rr* that approach to meet at R in 2, and creases *pp* that meet at P in 2. In 3, 2 is prepared for a rotation through two right angles about the fixed axis PR, through the crossing P and the crease-kiss R, or, as a more learned man would say, through the decussation P and the plicatorial osculation R—taking 2 for ${}_9Aj$: exchange here P and R if 2 is ${}_9Ar^2$. In 4 the rotation is effected, undoing the crossing P of 3, which has become a kiss P′ in 4, while the kiss R of 3 has become the crossing R′ in 4, if 3 is ${}_9Aj$: exchange here P and R, if 3 is ${}_9Ar^2$. In 5 the crease kiss is undone, and ${}_9\mathrm{A}j$ has been twisted into ${}_9\mathrm{A}q$, as ${}_9\mathrm{A}r^2$ has into ${}_9\mathrm{A}b$, both by the twist of Tait, which is above analysed. In Tait's twist the part rotated is not the same figure between P and R after rotation as before.



There may, of course, be any number of crossings in the rotating part about PR.

If here we consider P and R as both crossings, 3 and 4 are two unsolids of ten crossings, complementaries of each other about PR.

When the knot to be twisted is such that the rotated part is the same after rotation as before, 3 has no complementary, and the result is simply one pair of convertibles, viz., K on the left instead of ${}_9\mathrm{A}j$, turned into K′ on the right instead of ${}_9\mathrm{A}qj$, and not two pairs as here, ${}_9\mathrm{A}j$ turned into ${}_9\mathrm{A}q$ and ${}_9\mathrm{A}r^2$ into ${}_9\mathrm{A}b$.

If, in the above process, we have only two summits *a* and *b* between P and R in 3, making the 2-gon *ab* collateral with the triangles *ab*P and *ab*R, we have the simplest possible case of twisting; and in this the rotation makes no change, 4 and 3 being as projections identical.

This is the twist of Listing, who found it in his study of knots of seven crossings, under what seems to me the needless disguise of gracefully flowing curves. It was sharp wit in Listing so to observe it; it was still more acute in Tait to detect under a more complete disguise the manœuvre of his twist of greater complexity.

The figures 3 and 4, considered as unsolids of ten crossings, are the complementary pair **C**71 and **C**74. If we had these two before we had obtained ${}_9Aj$, ${}_9Aq$, ${}_9Ar^2$, and ${}_9Ab$, all of which are subsolids to be regularly constructed by their leading flaps, we could, without the minute comparisons of that process, at once draw these subsolids—the first pair by unkissing at R and P′, the second by unkissing at P and R′. And if we had all the unsolids of ten crossings, having each a linear section PR, which cuts away on both hands a $(3+r)$-gonal mesh, we could with the same ease draw every knot of nine crossings that has a triangular section Prr. All we have to do is to take first every complementary pair of 10-fold unsolids, and by unkissing, as just shown, write down from it two couples of 9-fold convertibles; next to take every unsolid 10-fold without complementary, which has a linear section PR, above described, of which the two crossings P and R are not identical, and by unkissing first at P and then at R, to obtain from each such unsolid one couple of convertibles. The remaining unsolids in which those crossings P and R are identical will give, by unkissing at either in each, every 9-fold not already found which has a linear section Prr; where the words just used, "remaining unsolids," include every unsolid before handled as having a section PR with P and R unlike, to be handled again once, twice, &c., according as it has one, two, &c., different linear sections PR with P and R alike. And every 9-fold so got from P and R alike is a 9-fold having a triangular section at which it can be twisted into its reflected image. It will sometimes happen that amongst our couples obtained of convertibles, AB, BC, &c., the couple CC will be found. This means that the knot C has two different sections, Prr and Stt, at which it can be twisted into itself, besides one or more at which it can be twisted into B or B′ of the couples BC and B′C. For the truth is, that the number of different crossings P in the linear sections PR on all the knots of n crossings is exactly the number of different triangular sections Prr, above described, on all the knots of $n-1$ crossings. We shall obtain repetitions of some nine-folds, but no vain repetition; for when the unkissing is finished we shall have grouped all the convertibles in twos, threes, sixes, &c., without ever attempting to perform a twist, as well as have given an accurate account of the number of different triangular sections on the grouped ones and on the uniques, without ever trying to count these sections, or to distinguish them by their symmetry.

In all that precedes, no distinction is made or supposed between unifilar and plurifil knots; nor do I know any reason why unifilars only should be considered.

The crossing P in fig. 1 may stand for any tessarace in the projection of any knot, or of any n-acron whatever, through which lies the triangular section Prr there described. The twisting can take place in them all, no matter what the faces and the other $n-1$ summits may be, and the groups can be formed of which every figure can be so twisted into one or more of the others.

The question here presents itself—Will it be profitable, supposing that the census of all the knots of n crossings is wanted, to employ the method of unkissing above opened? I am of opinion that it will.

Let the subsolids (which have no linear section PR) be divided into S_n, all that have no triangular section Prr cutting away on both hands a $(3+r)$-gonal mesh, and T_n, all those which admit one or more such sections Prr, and let U_n comprise all the unsolids, which have each one or more linear sections PR, cutting away on each hand a $(3+r)$-gonal mesh.

Suppose that S_n and U_n are found, and that the subsolids T_n, in general more numerous than S_n, are wanting. If we can obtain U_{n+1}, we shall readily get by the simple process of unkissing, not only the missing T_n, but every pair of convertibles possible out of T_n and the unsolids U_n that admit a triangular section Prr, and every fact required for our table of uniques and grouped convertibles.

I believe that even when U_{n+1} is more numerous than T_n, it can be more easily found than T_n, which comprises only subsolids to be obtained by the minute and often many comparisons that determine the leading flap; whereas U_{n+1} is rapidly put together without minute comparisons by laying 2 upon $n-1$, 3 upon $n-2$, &c., by the simplest marginal sections *ffc* only.

The reader, having before him in the plates of vol. xxxii. *Trans. R.S.E.* nearly all the knots unifilar or not of fewer than ten crossings, can amuse himself by considering the question above proposed. He can begin with $S_5 = {}_5B + {}_5C$. Compounds like ${}_6E$ are rejected all through. But the student will not be able to confine his attention to unifilars only.

Observe that in the linear sections PR neither P nor R can be a non-terminal crossing of a plural flap. Also, if in PR R is a crossing of the 2-gon RR′, PR and PR′ are for our purpose the same linear section, because we get the same n-fold knot whether we unkiss at R or at R′ upon the $(n+1)$-fold. Hence it follows that Prr and P$r'r'$ are the same triangular section when rRr and r'Rr' are covertical angles at the crossing R.

It is not difficult to give simple rules whereby S_n is found without error or repetition from S_{n-1} and S_{n-2} by the leading flap of each knot of S_n. But a definition of a fixed flap must be made and stuck to.

I conclude with two useful little theorems.

a. On every unsolid unifilar V in U_{n+1} each of its linear sections PR (P and R unlike) lies through four angles at P and R, which are all odd or all even.

b. The couples of n-folds obtained by unkissing on V, or on V and its complementary, are all unifilars or not, according as these angles (in a) are odd or not.

My objection to the twistings, that they put a twist upon the tape, has been answered by Tait. In the case of Listing's twist, I have satisfied myself that his answer is sufficient. It appears to me that it ought to be formally demonstrated as sufficient in all cases.

After all, as it is certainly not on record who invented kissing, it may come to be forgotten who invented unkissing.

P.S. Nov. 7.—I have learned how to form readily all the unifilars only of U_{n+1}, required for unifilar couples, by operating on unifilars only of n and of fewer crossings. I shall soon present to Professor Tait the requisite unifilars in U_{12}, and thus I hope to save him much time and trouble in grouping the unifilar convertibles of eleven crossings.

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